On the harmony of the comprehensible world. 1845

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ON

THE HARMONY

OF THE

COMPREHENSIBLE WORLD.

SAPERE AUDE.

LONDON:

1845.

PREFACE.

An unprejudiced examination of the connexion between the different sciences, which are treated by practical philosophers as distinct departments of human knowledge, will lead to the conclusion, that they are all portions of one complete harmony, and that the end of each series of events in the great system of Nature is the beginning of another. No modern naturalist believes that botanical or zoological phenomena are independent of the laws of chemistry and physics, or that astronomical changes can be disconnected, in a compendious scheme of cause and effect, from those which depend upon the elective affinities of minute portions in each distinct heavenly body.

That a continuously *self-sustained development of gradually varied forms* prevails throughout Nature, is one of the hypotheses necessarily suggested by a belief in the existence of the perfect harmony of her laws, not only in reference to zoology and botany, but to general physics, chemistry, astronomy, and every other branch of the mixed sciences; and it may be proved that this speculation about a *progressive development* may be extended to our most refined schemes of ontology and metaphysics.

The object of the following essays is to classify the evidence in support of such a doctrine, and to throw back the point of departure in the inquiry to our most elementary notions about primary substance, and the energetic or framing power of Nature. The proposed arrangement of the general argument commences with the attempt to investigate our most simple ideas, in regard to form and number, *in the abstract*; and proceeds to the application of the results of the analysis:—first, to general *physical* phenomena; secondly, to admitted *phrenological* and *psychological* facts, as regards the gradual development of mental faculties in animated bodies; thirdly, to those mysterious dogmas, which pervade the religious traditions of antiquity, but which are not inconsistent with an unprejudiced review of ancient and modern metaphysical opinions.

The whole scheme exhibits a connected system of mathematical, physical, physiological, metaphysical, and theological propositions, in which one omnipresent and unerring immaterial mind is considered the *universal* originating cause of the existence of every species or class of *individual* essence, be it inanimate or animated—material or spiritual. The inquiry induces a belief in the reality of a Supreme Creative energy, which is constantly engaged in promoting the *automatic* development of *successive series* of individual beings, whose qualities may at last hold some remote phrenological relation to those of the omnipresent Divine Intelligence, when their sensation and volition become more or less independent of the slavish instincts which are connected with mere physical necessity.

In the present volume the investigation does not advance beyond the domain of physics and elementary chemistry, and the first principles of physiology; in another, already prepared for the press, the argument is extended to those more recondite questions of psychology, which must be connected with every phrenological scheme of sensation and volition, and the generation of ideas.

The still more delicate subject of natural and metaphysical religion, in reference to the progressive development of mental faculties in created beings, and their capabilities of comprehending the mysteries of Superhuman Power, or of availing themselves of the highest gifts of a Divine Providence, is only cursorily hinted at in the second volume. In the existing condition of human society, it would be rash to publish speculations which interfere with the conventional disinclination to examine the bearing of generally admitted facts upon such questions.

But no such scruples should be allowed to interpose between the soul-denying materialist, who believes himself to be the model of the whole macrocosm, or who makes his God the mere counterpart of his own limited intelligence,—and the more humble-minded searcher after truth, who is convinced, that there are mysteries in the universe far beyond the scope of human reason. Many modern naturalists, who establish physical limits to philosophical investigation, confine their inquiries to phenomena alone, and parade a pedantic horror of speculation upon the highest conceivable causes of such phenomena, while they endeavour to find an excuse for their *absolute* method of scepticism, by affirming that they do not meddle with metaphysics. Yet, they are always upon the frontier of metaphysical inquiry, when they talk of *ultimate* atoms. The assumption that these distinct atomic material individuals are realities, involves a necessity for the existence of interstices between them; the special conditions of such interstices are legitimate objects of physical meditation. It is is *physical* problem, whether these interstices are filled by matter, or are void, —whether the atoms are subject to change, or are eternally the same,—and whether they are composed of the same substance as that which may fill up the interstices between them, or of some substance which is essentially different.

As materialists deal with physical forces in all physiological questions, they are inconsistent in dismissing these difficulties, under the pretence of their being metaphysical; and when they endeavour to depreciate the labours of others, who may be more speculative than themselves, their didactic mode of imposing limits to scientific inquiry, resembles that of the bigot in religion, whose denunciations against the liberty of thought are the constant theme of their own severe animadversions.

The professed metaphysician, who looks down with a mystical pity on the materialist, is equally unreasonable; and unless he condescend to examine the instincts of animals, and of his own race, in reference to the faculties of the mind, he is wholly disqualified from reasoning by analogy. In Hume's Essays, where he boldly enters into the most abstruse disquisitions upon abstract power, and cause and effect,—his ignorance of the first principles of natural science appears in the whole argument. But metaphysics and physics are inseparably connected. The human mind and its powers are dependent, to a greater or less extent, upon the matter which constitutes the nervous system of the human body; and the *elementary* energies of matter must be in constant activity, as *mediate* causes of phenomena, whether the simplest law of chemical combination, or the most transcendental faculties of the *human* mind, be the subject of our investigation.

When we reason by analogy, we have *primâ facie* grounds for the assumption, that as the laws of nature exhibit an universal order and arrangement, which is precisely similar to a plan conceivable by a human mind, so far as our bounded intelligence is capable of understanding it,—there is something in common between our minds and the Universal Mind. And although we cannot comprehend the essential character of that all-presiding influence, we may infer that it is not the same thing as matter, because matter, in its totality, is subject to it.

But in our attempts to discover the physical causes of material phenomena, we arrive at last at the notion of individualised atomic forces, which may be regarded as constituent germs of the whole scheme of nature; and as it is possible to imagine a non-atomic condition of matter, which enables it to fill up the interstices between ultimate atoms, we are strictly within the limits of true philosophy, when we suppose the atom itself to be a generated entity, having a temporal beginning and an end, in relation to its form, to its every quality, and indeed to its individual being, without thereby assuming that the substance out of which it is composed, was not a pre-existing material applied to such a purpose. This hypothesis, however, cannot be suggested without giving rise to the inquiry of whether the *primary* substance does not occupy space universally ; the materialist, therefore, who halts when the interstices between atoms are the subject of inquiry, is incorrect in declaring that such a question is a metaphysical problem. The problem involved in the relations of matter to space, is one of physics ; and when we endeavour to account for the generation of the atom, we are still employed in the consideration of physical laws, although the attempt to connect the order of nature with *mind, as its cause*, leads us up to that stage of philosophy, which may be termed metaphysics in the ordinary phraseology of science.

The general term metaphysics is applicable to two distinct branches of scientific study,—the one being connected with an inquiry into the attributes, power, and subjection of mind in animated bodies, where the elements of physics and psychology must be regarded as intimately dependent on each other ;—the other having reference to those *ideas*, which are altogether independent of matter and of mere physical laws.

It is only in relation to our ideas of logical, metaphysical, and mathematical truths, that abstract elements of the higher order can be considered apart from the physical phenomena which depend upon them. The *absolute* existence of these *model truths* is equally clear to our comprehension, whether they be connected with physics, or treated as pure abstractions. They should be analysed in their purely ideal character, before any attempt is made to reconcile our theological opinions with the observations of the naturalists: the more deeply we meditate upon them, the less likely shall we be to fall into errors like those of the savage, who believes that an eclipse of the Sun is the *immediate* act of the Supreme Being, or to attribute the existing form of any specific material individual (or of the first individuals in any specific series of animals or vegetables, which is continued by the automatic agency of their parents) to a sudden and *human-like* interposition of that One incomprehensible Disposer of events, who acts through the instrumentality of the instinctive aptitudes which he has attached to material substance. The whole scheme of Nature will then appear to be one well-connected system of cause and effect, the plan, and the maintaining energy of which depend *essentially* upon the intelligence and power of the Almighty.

Plato, in his "Parmenides," has entered more deeply into the transcendental metaphysics which lead to the study of the First Cause, than any other ancient or modern writer. The careful perusal of that master treatise in dialectical reasoning, ought to convince the materialist, that there are stages on stages in the higher branches of philosophy where the human intelligence may exercise its phrenological powers without the guidance of phenomena, but with as legitimate and perfect a reliance upon the certain connexion of the arguments, as if it were dealing with physical experiments or physiological observations.

It is in such efforts to investigate the connexion of the ideas which are independent of physical sensation, that we discover proofs of the existence of an incorporeal world. By gradually advancing from the contemplation of matter and its instinctive laws, to that of the *one design* which pervades the entire system of Nature,—while we ponder upon abstract truths as a category still more sublime, because every principle can only be understood as an eternally-existing Ideal Essence, whose *absolute being* is necessary to the harmony of Nature,—we may at last attain the metaphysical limits between physics and the inexplicable mysteries which are connected with a purely spiritual condition of existence.

The third of the following Essays was printed, but not published, in 1842, as a separate treatise. The second Essay, on the "Outlines of a Physical

Theory," was an appendix to that treatise on Numbers: but as the form in which it was printed, was inconvenient,—in consequence of the number of notes,—it has been entirely remodelled, and the greater portion of its notes have been embodied in the text.

During the interval a compendious work has made its appearance under the title of "Vestiges of the Natural History of the Creation." That very popular publication is not only remarkable for the grasp of mind which it exhibits, but for the skilful arrangement of information, communicated in language as appropriate as it is elegant; and its author has been successful in a well-sustained endeavour to direct public attention to some of the most interesting problems in Natural History. Although a fellow-labourer in the pursuit of the same object, the writer of the following Essays entertains no hope of meeting with the like success: his attempt to discover an elementary basis for the theory of "gradual development," which is so artistically delineated in the "Vestiges of Creation," has involved him in a succession of calculations and minute details upon form and number in the abstract. Even with respect to his physical hypothesis, where he endeavours to extend the theory to first principles in chemistry, he has found it necessary to adopt a method which may be tedious to those who, under the guidance of the author of the "Vestiges," have commenced their survey of Nature, by meditating upon astronomical harmonies.

The general title prefixed to the present volume was selected in preference to one which might have appeared more simple and euphonious, but which would have been inaccurate. There is an incomprehensible as well as a comprehensible world. The "Universe" includes both one and the other: but to have termed this series of Essays a treatise "on the Harmony of the Universe," would have justly exposed the writer to the charge of arrogance. The *universe*, as a whole, is beyond human comprehension, whether it be considered metaphysically or theologically.

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THE reader is recommended to make the following corrections, more especially as regards the cyphers, before perusing the volume.

CORRIGENDA.

FIRST ESSAY.

PAGE

xi. Fourth line from below, for "is," read "*in.*"

xxxv. In note, sixth line from below, for "may deduced," read "may *be* deduced."

lix. Eighth line from below, for "collape," read "*collapse.*"

lxi. Eleventh line from above, for "EH*b*," read "EHG."

SECOND ESSAY.

lxxii. Fourth line from below, for "Boscovitz," read "*Boscovich.*"

cxi. Thirteenth line from above, for "weight," read "*eight.*"

cxvii. Thirteenth line from above, for "circle of latitude," read "*circle of its latitude.*"

cxxx. Tenth line—and cl, fourteenth line from below, for "hypothecated," read "*hypotheticated.*"

cxxxiii. Fifteenth line from bottom, dele "attraction and."

cccxiii. Fifteenth line from below, for "Johnstone," read "*Johnson.*"

cccxxvii. Eleventh line from below, for "however *he* exalted," read "*however exalted.*"

THIRD ESSAY.

15. Last word in note, for "hyperbola," read "*ellipse.*"

41. Second line from below, for "7 and 8," read "2 and 8."

56. Ninth line from below, for "or," read "*on.*"

58. Fifteenth line from below, for "proceding," read "*proceeding.*"

61. Thirteenth line from below, for "left," read "*right.*"

64. Second line in note, for "next chapter," read "*next Essay.*"

79. In upper circle of the septuple figure, *transpose* the cyphers 3 and 5.

126. In diagram, alter the second circle from below, in the left hand column, as follows.—

$$\text{For}\quad\begin{array}{ccccc} & & 4 & & \\ & & | & & \\ 3 & \text{—} & 10 & \text{—} & 33 \\ & & | & & \\ & & 6 & & \end{array}\qquad\text{read}\qquad\begin{array}{ccccc} & & 4 & & \\ & & | & & \\ 3 & \text{—} & 6 & \text{—} & 18 \\ & & | & & \\ & & 7 & & \end{array}$$

129. Thirteeth line from below, for $\frac{40}{143}$ read $\frac{40}{146}$.

FOURTH ESSAY.

141. Thirteenth line from above, for "indicatives," read "*indicators.*"

ESSAY I.

ON THE GRADUATED SELF-DEVELOPMENT OF SOME FORMAL IDEAS, WHICH ARE GENERATED IN THE HUMAN MIND BY THE INNATE POWER OF ITS REASON, WITHOUT REFERENCE TO THE PHENOMENA OF THE MATERIAL WORLD.

SECTION I.—Introduction.

On elementary ideas in relation to the prevalence of certain typical *forms and numbers, which are peculiar to categories of genera and species.*

The Linnean classification of plants is mainly determined by grouping them in classes and orders which are almost all distinguished from each other by their respective typical quantities of stamens and pistils. All terrestrial mammifers have *seven* cervical vertebræ. The relative proportions of the simple constituents in a compound chemical body—the relative mean distances of the planets from the Sun—the laws of music—and all other special systems of physical regulations which affect the combinations and mutual relations of distinct material entities—are based upon the abstract laws of one general and harmonious series of numbers.

No phenomena in Nature can depend upon chance. It cannot be a mere accident that the necks of the graceful giraffe and the compact mole should contain the same quantity of vertebræ. There must be some special reason for the constant prevalence of this sort of controlling influence over organisations, so dissimilar in many respects as those of two such animals; there is no subject more worthy the attention of the thoughtful naturalist than the existence of this extensive law, because it suggests that Nature, in her manifold mechanical contrivances, has been compelled to accommodate her *inventive* intelligence to an abstract *numerical necessity*, which is as powerful in its control as any dynamical or statical law. The object in view cannot be the comfort and well-being of the animal; for the usual argument about fitness or convenience is inapplicable in this instance. Moreover, the regulation differs according to the class of animal under consideration. The number of cervical vertebræ in the birds is not a *limited* quantity of the same classical character; it varies according to the length of the neck: the law in question only applies to the mammalia.

In meditating upon the difficulty, we arrive at the conclusion that this, or any other limitation, (as to the definite quantity of parts in each category), can only depend upon some regulation in the great system of the universe, which harmonises with one entire scheme of abstract necessities. But this need not preclude us from endeavouring to discover *why* such laws are in operation; neither should it compel a belief that there is that sort of *absolute* and independent power in any particular number, which was venerated by some of the Pythagoreans, as if it had godlike attributes.

The ancients, who devoted so much thought to elementary principles, considered the mathematical sciences as the foundation of all philosophy, while they treated pure arithmetic as the first of mathematical sciences: they maintained that our ideas of numbers may not only be independent of any material objects of our perception, but even of those geometrical ideas of form which the mathematician is able to conceive without thinking of the spacial qualities of physical bodies. Most of their treatises upon this branch of contemplative study, which have survived the barbarism of the dark ages, expatiate upon traditions about the mystical powers of numbers; and magical influences were attributed to certain ideas of quantity, independently of geometry or of pure arithmetical processes.

The Pythagoreans and Platonists, however, with whom such doctrines were more or less in favour, did not sufficiently define the decided distinction which may be observed between the *absolute* arithmetical properties of numbers and such of their contingent qualities as are entirely dependent upon their connexion with *geometrical* ideas,—although in some instances a harmony between numbers and geometry was supposed to impart additional mystic virtues to numbers holding an obvious relation to such *forms* as were deemed the most perfect types of *geometrical beauty*. The criticisms of Aristotle, in the 13th and 14th books of his Metaphysics, where he is severe upon the doctrines of the Pythagoreans and of Plato about the *divine* attributes of numbers, are mainly based upon his confounding the abstract laws of pure arithmetic with those elementary ideas of numbers, which are suggested by meditating upon the self-development of a series of geometrical forms.

There are evidently three modes of considering numbers, as *powers*, or *types of powerful laws*, in relation to the order observable in the phenomena of the material world.

First. A number may be regarded *mystically*, as a sort of *principle* or an essential being which possesses some *absolute* quality of its own, independently of its mechanical application to arithmetical processes of calculation. Although we have no means of knowing whether Pythagoras himself inculcated this tenet, it is evident that some of his successors did so; they *deified* certain numbers, and the sarcasms of Aristotle were directed against the believers in such doctrines. The modern naturalist would at once reject any superstition of this description, without wasting his time in the endeavour to confute it.

Secondly. The governing arithmetical qualities of certain numbers in relation to each other, coincide with physical observations, which tend to prove that some have a more general and paramount influence than others in every physical scheme of the arrangement or combination of individuals. The *internal* predominance of any given number in the pure arithmetical scheme, may be a reason for its prevalence as a type of a fixed quantity of material individual constituents in any physical category or combination, and of limitations as to the forms and the other *specific* relations of such combinations.

Thirdly. When we derive the idea of a series of *numbers* from a *self-developing* geometrical series of *forms*, by meditating upon abstract principles of necessity in relation to form,—the leading terms of quantity which will be thus suggested, are not the same as those which the *pure* arithmetician would consider the most important on account of their merely arithmetical properties.

It is in this contingent, or secondary numerical system, which is dependent on a self-development of geometrical forms or *spacial figures*, that the naturalist will be most likely to discover the *elementary* reasons, why certain numbers have an influence in the material world,—because it is a legitimate inference, that the physical laws which prevail in space over matter, should be founded on a geometrical, rather than upon a purely arithmetical, basis. We shall find an insurmountable difficulty in attempting to determine why the number *seven*, for instance, should be of such importance as it undoubtedly is in Nature, if we only ponder upon its mere arithmetical properties; but when we search for the cause of the influence of this definite quantity, by investigating the problem *spacially* or geometrically, an obvious reason is suggested, why *seven* should be a primary type of material combination.

We shall also discover that the geometrical series thus constructed, is *formally* applicable to our most elementary ideas of material forms,—that all its numerical concatenation gradually appears in the progressively complicated combinations of material molecules, and bodily organs,—(a fact demonstrable by the chemist as well as by the botanical and zoological anatomist),—and that this geometrically-derived series blends itself most harmoniously with the more elementary one of pure arithmetic. Its own internal relations constitute as beautiful and perfect a scheme of self-adjustment as that of a multiplication table or a system of logarithms; and they serve in a remarkable manner to support the hypothesis,—that the geometrical method of accounting for the prevalence of certain numbers in Nature's numerical types, is the most reasonable mode of undertaking the solution of the problem. They will then seem to have been selected by the Great Architect, for formal and elementary reasons, which would have influenced the intelligence of a human creature, who had to determine upon the most obvious general plan of selecting *definite* ideas of quantity, as elementary standards for the construction of his handiwork.

The object of the present essay is to analyse some of the simplest geometrical ideas in relation to the self-development of a series of forms, in which each new form has a more complicated character than that from which it is derived. We can account for the *automatic* generation of every geometrical figure, until we reduce the *elements* of the *formal scheme* to *space*, and any *two given points* in it as the original substance (if the word be admissible) of all our ideas of form. The *generation* of every new figure is the result of the most obvious method of attributing *motion* to some part or parts of a more simple figure, while other parts are supposed to be at rest,—or of imagining these opposite conditions of the parts of any such existing figure to be reversed,—those previously at rest being supposed to move, and *vice versâ.*

It may be shown, that this progressive method of *formal* self-development has its analogue in an accompanying series of numbers which it suggests,—that there is a complete harmony between such a numerical succession, and numerical influences of the highest order, which seem to have controlled the phenomena of Nature,—and that the hypothetical doctrine of *heterogenesis* and the *transmutation of species,* is corroborated by the mathematical certainties made manifest in the abstract sequence and connexion of such forms and numbers.

In a part of Plato's *Timeus,* where he assumes, that the world was constructed in reference to certain numbers which were derived from ideal forms, he is mystical upon the virtues of certain geometrical figures. This is the more extraordinary, since he accounts for the idea of the generation of a circle as a first operation in the Divine mind, and shows in the same treatise, *how* that idea was conceived by the application of motion to a straight line. We must therefore conclude that his geometrical scheme, although based upon correct elementary data, was an incomplete analysis, and that he had not attained a full conviction of the power of *motion* in relation to the development of *every* sort of formal idea.

Whether Pythagoras taught his own discoveries upon the virtues and powers of numbers, or repeated the doctrines he had heard in Egypt and Asia,—and whether such opinions were wholly founded upon abstract arithmetical considerations without reference to geometry, or upon an intimate knowledge of the laws of Nature, and of geometrical mathematics,—are questions which history does not elucidate: but we are informed, that "he believed that the comprehensible world was formed out of a shapeless heap of passive matter, by the intervention of a powerful Being, who was himself its mover and soul, and of whose substance the souls of mankind were a portion. He considered numbers the principle of everything, and perceived in the whole system of the world, regularity, correspondence, beauty, proportion and harmony, as intentionally produced by its framer."

Like other abstract truths of all descriptions, those of numbers, according to our judgment, must be imperishable and eternal, holding no relations to time or space in their abstract characters. Superiority or precedence in regard to a beginning of existence, cannot be applicable to any mathematical or arithmetical truth, when it is considered singly or abstractedly; but in the geometrical process of generating one imaginary mathematical form, by compounding or combining others of a more simple character,—or, in the arithmetical one, of producing a third number by adding two numbers together, or by multiplying or dividing one by another,—the new idea holds a relation of *subsequence* to those from which it was generated, *and has its beginning* in regard to the process by which it was made manifest to our minds.

Hence it is evident, that every mathematical and arithmetical truth has two sorts of qualities in our minds: that which gives it its absolute certainty, suggests the notion of an eternal, never-beginning, never-ending existence; that, on the contrary, which attributes to it a relation to other ideas, connects it with our conception of its origin in our imaginations. And this distinction is very important, since it is equally obvious, whether we consider the laws of mathematics and arithmetic in reference to the ideal or to the material world; for human reason is capable of conceiving ideas in relation to *form* by a mental process of great simplicity, and the result is the self-suggestion of a series of numbers, succeeding each other in the order in which their respective influences seem to have been gradually developed in the system of Nature.

When we trace the origin of a series of ideas, which, like these are generated in the imagination without the aid of any observation of material objects, they will be found to hold an inevitable relation to each other. Should such ideas present themselves to our apprehension in a different succession at first, in consequence of some extrinsic influence on our minds, we can always adjust and arrange them afterwards, in their order of causes and effects.

General certainties, however, are, for the most part, suggested by our experience, in this discursive manner; but when they have an axiomatic character, they seem to hold no *necessary* relation to each other.

This remark applies to all our elementary ideas about *essential Being*. The notion of a *peculiar form* of matter, is wholly distinct from that of the absolute or essential *substance*, whose various *formal qualities* may have been developed by the processes of Nature; and although we may detach from it one quality after another, until we have reduced it to the *informal passive essence* imagined by the Pythagoreans, as the *basis* of the material world, we can never get rid of the basis itself. Aristotle endeavoured to do so, but failed; and philosophers in all ages engaged on the same problem, have been obliged to take refuge in a more or less vague doctrine of Pantheism, according to which all things are evolved from, and return into, the first incomprehensible principle.

But when this method of analysing our ideas is applied to those of form and number, we discover an immaterial mode of generating them, which has its analogy in the changes of the material world. Thus the ideal sphere may be said to be generated by the ideal circle, and the circle by the ideal straight line, and the straight line by the idea of two points, supposing *space* as the ideal-medium, *motion* as the active principle, and the *two points* as the essential substance,—to be three *basis-ideas* holding relations to each other. The idea of motion itself, however, may be referred to that of the *passing moment* in time, which is the most refined type of abstract progression.

In reference to our conception of such ideas, the human mind cannot conceive any other notion of a calculating *superhuman* reason, than that which is derived from its own reasoning powers; and unless we apply the analogy to Divine intelligence, it would be in vain to speculate upon the great problem of *why* the material world exists in its present conditions,—as regards those apparently automatic processes of Nature, which are all portions of one perfectly connected system. But if we suppose that our minds are the faint copies of the Divine mind, it is not presumptuous to imagine, as the Pythagoreans did, that a *superhuman intelligent Power* applied the inevitable certainties of mathematics to the manifestation of forms and other qualities in the material world, because they are ideas which human intelligence can conceive, independently of all those impressions which we derive from our perception of material phenomena.

It is true, that this mode of argument will never enable us to understand the grand mystery of Omnipotence in the abstract: because we can only advance to the frontier of that incomprehensible world, in which there can neither be a beginning nor an end. It was there that the earlier Pythagoreans halted, as may be seen in the "Timæus" of Plato, and yet more evidently is his "Parmenides," notwithstanding all the dialectical subtleties of that incomparable treatise. Paley, Butler, and other modern reasoners in this country, have not advanced so far; they have argued most ably upon the mechanical and social fitness of the architecture of the material world, without touching on the more recondite questions which are now before us.

According to the supposed system of Pythagoras, the material world, in its *informal* or aboriginal essence,—the moving, contriving, and all-pervading *soul of the universe*,—and the *abstract truths* of mathematics and arithmetic,—are all eternal principles or elements. And this *aboriginal* co-existence of the *three* distinct sorts of principles necessarily attributes a superiority to the numbers when considered in relation to the Divine Architect; such a doctrine deprived Him of omnipotence, as regards these abstract laws.

This difficulty was the great stumbling-block of the Pythagorean school, and was mainly the cause of the numerous sects into which it was soon divided, some of which, at last, professed atheism. The subsequent doctrine which was taught at Athens, in the days of Socrates and Plato, and which supposed the supremacy of an absolutely omnipotent Divinity who was distinct from the architect of the universe, *and was his superior*,—did not obviate the difficulty, because it was never attempted in that school to maintain that mathematical certainties were not inevitable truths.

But the theological dilemma does not interfere with the tenets of the Pythagoreans about the influence of numbers, nor does it invalidate the notion, that a great numerical law has prevailed in the material world, which is self-suggested to our reason, when we meditate upon the mode of deducing our ideas of number, or of an inevitable series of numbers, from mathematical or formal images, which are successively generated in the *human* mind by its own inherent powers.

Such being our preliminary meditations upon the only incontrovertible method of discovering the progression of a series of numbers, which may have been progressively dominant in the development of natural phenomena,—it remains to be seen whether we can construct a scheme of ideal numerical harmony, based upon elementary principles, which are of the simplest character, and which are suggested to our reason without referring to those phenomena themselves. If we can succeed in this undertaking, and can also demonstrate, by observation, that this ideal scheme has been applied in nature to the development of the various forms and qualities of an infinitely extended material substance, so as to account for those general and special laws of number, which are demonstrated by materialists,—we shall have solved the problem under consideration, and explained *why* such rules in regard to quantity and proportion have prevailed in the physical world. But the theological question connected with it, is clearly beyond our solution; because however we may succeed in establishing an analogy between our own limited intelligence, and the universal intelligent Power, which ordains that the matter of the physical world should arrange itself in accordance with the abstract rules of mathematics, and of a mathematically-originated series of numbers, we cannot invest the abstract intelligence of the universe with the supreme attribute of *omnipotence* if we suppose it to act *in obedience* to *any* inevitable ideas of number and form, which must have existed as laws from all eternity, according to our judgment, and which will exist for ever.

It is easy to understand, why the Pythagoreans asserted that numbers were the *principle* of all things; and as human reason is prone to personify its abstract ideas of power, the tendency of such an aphorism was to invest numbers themselves with a certain divine attribute of omnipotence. But we have shown, that as soon as we arrive at this stage of logical argument, our reason is an insufficient guide, and no analogy will assist us in the endeavour to prove *how* the Supreme *Will* can be independent of the abstract rules of mathematics and arithmetic. Instead, therefore, of following the later Pythagoreans in their last and highest attempt, we shall be acting more wisely and reasonably, if we admit that when analogical argument and our ideas of beginning and end, are inapplicable, as is the case in regard to our notions of abstract mathematical and arithmetical truths and of *supreme power*,—we are unable to explain the mystery by any effort of human reason. A similar difficulty is self-evident, when we attempt to reconcile the apparent opposites of an omnipotent Providence and a subordinate free-will, or of the coexistence of good and evil.

All such questions confound the most accurate logician. He wanders in the dark when he attempts their solution, and becomes involved in an endless succession of the most startling paradoxes.

SECTION II.

On Time and Space, as elementary ideas or basis principles of all human notions about number and form.

When we endeavour to reduce our most simple ideas of mathematical figures to first principles, we find that it is possible to analyse such images by supposing them to consist of elementary lines. But as a straight line is the formal representative of a limited distance between two points, such constituents of an ideal cube, square or triangle, cannot be considered as its *ultimate* elements : these elements are points in space, as well as space itself, which is the *medium* of the ideal development of distances between mathematical points.

The idea of the development of a progression in time, or of succession in the abstract, may in like manner be referred to the *passing* moment, and to Time,—as its elements; the passing moment being the most simple type of abstract motion; and never-beginning, never-ending Time, being the *ideal medium* in which it is constantly advancing.

It is indisputable, that time, space, the present moment, and the mathematical point, are separate and distinct conceptions of our minds, to which we cannot apply our notions of birth or death, or of a temporal beginning and an end: in order to be thoroughly satisfied of this certainty, we may commence our investigations by considering the sophisms which have prevailed, both in ancient and modern periods of philosophical disputation, upon the nature of Time and Space.

Absolute space can have no bounds; however vast the region which the astronomer can inspect with the aid of the most powerful telescope, or that which he can imagine as the theatre of cosmical operations, there must be space beyond its limits. We may fancy one conventional boundary after another in the immeasurable expanse of heaven, without being ever nearer an *ultimate* frontier. To suppose, that there can be any boundary to Space, is one of those notions of childhood which ought to be dispelled by the simplest effort of an unprejudiced mind. The ordinary remark, that it is impossible to comprehend Infinity, seems absurd; yet some of the wisest among the ancient philosophers argued cosmologically, as if the spacial universe could be absolutely bounded. The same mode of reasoning is applicable to an infinite succession of periods in time; and we thus arrive at the idea of infinity in extension and duration, whether we ponder on Space or Time, with the conviction that their having the attribute of *endlessness,* is a self-evident and comprehensible necessity.

When we study transcendental philosophy, it is requisite to examine the opinions of profound thinkers, some of whom have treated the enquiry into the nature of Time and Space, as one of the most important in metaphysics; and this becomes more necessary, because it has been maintained, with much appearance of sound logic, that our notions of Time and Space are those of things which are created by, or imagined in, the mind, as *relations* to other ideas, instead of being present to our understanding as objects of thought, which have as real an *existence out of our imagination*, as any perceptible body has.

We have been told *categorically* that neither Time nor Space is a reality, but a "mental receptivity" or a created postulate of our reason, necessary to our mode of explaining phenomena;—in other words, that they are *hypothetical* media for the action of substance as regards succession and extension, but that neither Time nor Space is comprehensible as an *absolutely existing* thing, and that our only method of definition is to treat them as *receptivities*, *media*, or *relations*. This opinion, and most others, which attribute our ideas about the reality of Time and Space, to the creations of our own fancy, may be analysed without casuistry; and as the subject involves no question of doubtful perception through the senses, it is explicable in conventional terms, which may convey a clear and concise exposition of the whole argument.

Our simplest mode of arriving at the comprehension of *infinite* space and *eternal* time, is by supposing that they convey the same ideas to the mind, as those of universal extension, and never-beginning and never-ending duration: (*a*)

(*a*) One of the least objectionable modes of stating the opinion, that time is a relation, because the author's argument is advanced with admirable clearness, is to be found in Monboddo's Ancient Metaphysics. He says (Book 4, chap. i.), "If nothing existed, it is evident there could be no such thing as 'time.' Further, if there were no continuation of existence, there could be no *time*, because there would be nothing but it may be shown that extension and duration are merely properties, attributes, or qualities of time and space: their synonyms they cannot be. It is true, they afford us a graphic notion of the striking characteristics of time and space, because they express the simplest mode of comprehending that time and space are everlasting and infinite realities. But if we want synonyms, eternity and infinity would be more appropriate verbal representations of the objects themselves, than duration and extension are; because they express the main characteristics of time and space, while the words duration and extension are terms, which only have reference to our

to which it could be applied. This continuation of existence is what is called *duration*. Further still, as time is acknowledged by everybody to be a *measure* of something; and as we conceive it to be applied to nothing but *duration* (for it cannot be applied to quantity, that is, to magnitude and number, nor to quality, substance, or any other of the categories considered absolutely in themselves, and without respect to *duration*) it follows, that time is the measure of duration." He adds, "We can make the definition of time a little more particular by saying that it is the measure of duration of beings liable to change or succession."

He follows Aristotle in attributing our first notion of time to our idea of motion.

The error here lays bare the whole faulty mode of argument by which some persons who are less clear than Monboddo, satisfy themselves that time is a relation: what they call time is, in reality, *a period of time*. His logical mind, however, did not admit, that duration is anything more than a relation to something existing. Infinity with him is precisely what time is in its literal meaning,—the infinite abstract medium of *continuous being*.

In the same chapter, he says, "As there is no time without *motion*, so *there is no motion without body*,"—and again, "it is of necessity that both time and motion should participate of the qualities of body *from which they are derived*,"—sentences which remove all doubt about his ideas of time being those of *time measured by material events*, which sentences demonstrate the error of the whole argument.

Suppose we were to clothe it in the following words, by substituting,—the ship for the body,—the sailing of the ship for the motion of the body,—and the ocean for time. "There is no sea without sailing, and there is no sailing without a sailing vessel, ergo there is no sea without a ship!"

Time is the sea of all action, but if there were no action or moving body, the infinite potential medium, time, would still exist, like the sea on which no vessel ever sailed. Monboddo's method inverts the course of the syllogism, and is logically wrong. The sailing-ship requires a medium in which it is to sail; but the sea, the medium in question, stands in no need of the ship. All conceivable action requires a portion of time, and the motion of a material body must take place in a portion of infinite space: but these media of continuous action, or motion, exist independently of all such events.

mode of attaining ideas of infinity and eternity. Yet infinity and eternity, themselves, are terms of relation, as they express the connexion between time and periods of time, or space and regions of space, besides being contingent on our ideas of "beginning and end," which ideas are completely relative.

It is self-evident that the *present instant*, and the ideal *mathematical point*, can have neither duration nor extension; and unless the *present* moment be connected with the *past* or *future* (as the passing moment), it does not even bear a relation to our idea of *duration*. The same argument applies equally to the idea of relative *extension*, so soon as we bring the mathematical point into connexion with other points; for a *solitary* point in space conveys no idea of extension.

But the method of argument, which leads so many metaphysicians to the conclusion, that space and time are merely *media* or "receptivities," ideally created (as it were) for the occasion, by the thinking mind,—has been also advanced to prove, that the present moment and the mathematical point have no absolute existence out of the imagination of the person who makes use of such ideas, as elementary *data* in analysis. It is indeed more difficult to demonstrate that they exist absolutely in the ideal world, as abstract and general certainties, because they are only present in the mind, when it is occupied in analytical study; while time and space, as universals, are constantly in our thoughts.

No casuist can deny, that the idea of the *present* instant *in* Time is distinct from that of a measurable moment of Time; and the notion that the ideal point *in* Space is a portion *of* Space, is so untenable, that no reasonable person would suggest a doubt about the idea of a point in space being independent of all ideas of extension.

The present instant in Time *seems* to have a double character, which is not the case with the mathematical point in Space; since it may have the appearance of becoming a portion of the *future*, or of having been a part of *past* Time ; yet this is *logically* impossible, because its existence as the *present* moment (the very condition of the question under consideration) precludes the possibility of its being *past*. This illusion does not present itself, however, in regard to the mathematical point in space, because we cannot imagine a point being part of a distance : the *moving* point maintains its identity ; and it is as easy to imagine a movable point in a line, as in boundless space. But the ideas of the absolute and solitary present moment in Time, and of the mathematical point in Space, are precisely of the same class ; both are perfectly independent of all other ideas ; and both hold equal rank with that feeling of *self-existence*, which is independent of the contingent relations of "having been," or of "about to be." Thus, it is evident that the present moment and the mathematical point in space, are elementary *necessities* in metaphysics, and that they are not relations to other objects, although the ideas which we entertain of their existence, are altogether opposite to those of absolute Time and Space.

We may call Time and Space what we please ; they are undoubtedly media, or "mental receptivities," according to the phraseology of Kant,—but, nevertheless, they are realities *in the ideal world*, and no legitimate mode of argument will reduce them to relations. The simple ideas of the present moment or of the mathematical point, are not relative to any other ideas, *unless they be the foundation or original basis of such other ideas.* They must have been ever present in the mind of the Great Architect of the physical world as elementary ideas, together with those of Time and Space.

Hence we conclude, that the *four primary ideal realities*, which are independent of all other objects of our thoughts, but which are, nevertheless, necessary basis-elements in every physical theory, *when it is considered metaphysically*, are,—1, time ; 2, space ; 3, the present moment ; 4, the mathematical point ;—and this result of our opposition to the dogma, that Time and Space are merely relations to substance and its action, will aid our efforts to comprehend some of the more difficult problems of transcendental philosophy.

SECTION III.

On the abstract contraries of the Infinitely Vast and Infinitely Minute, and on our simplest idea of motion in the abstract.

It is not difficult to attain a satisfactory idea of the *infinitely vast*, because it is an obvious relation to infinity; and infinity itself is a relation to everlasting Time and boundless Space, both of which convey a *primâ facie* notion of things infinitely large: but it is impossible to conceive anything *infinitely small*, without a much more logical consideration of that sort of infinity than of the other.

We cannot imagine the existence of any object in the material world which is not capable of division: it is true, that the atom or last elementary molecule of matter, which is supposed to be the basis of all corpuscular form, conveys the idea of indivisibility in a defining term; but as "great and small," in the material world are merely relations of comparison between various objects of our perception, we soon discover that *no material phenomenon will bring the idea of the infinitely small before us in a measurable form;* and if we reflect on the subject, we must at last surmise, that the *elementary* existence of any such portion of the material world as an indivisible atom, is very doubtful, because the term "atom" almost precludes the possibility of the object in question having any attribute of size or of its occupying Space *exclusively*.(*b*)

Our fundamental feeling of "I am," undoubtedly suggests

(*b*) In another part of this treatise, it is shown that the *indivisible* characteristic of the ultimate constituent molecule of chemical bodies may be only a temporary quality; the atom itself is most probably a physically generated entity, or a definite form, under which a certain quantity of material substance is embodied or individualised during a limited period of time.

the notion of indivisibility, as the attribute of a personal *essence*, which, although immaterial, is the basis of all our sensations. As regards psychology, the abstract idea of *infinite minuteness* may be realised in the existence of the soul. In the material world, however, we can discover no such realisation.

But the idea of the *infinitely small* is perfectly and immediately conveyed *to the mind*, in our conception of *the present* moment or of the *mathematical point;* and it is absolutely realised in either case, although its representatives have an abstract character. The present moment is indivisible and immeasurable; however short the period of a second or of a "twinkling of an eye,"(*c*) it is not the absolute present, which we can no more adequately describe or define, than we can measure it; the *present moment* is the abstract counterpart of the feeling of "I am" *now* in being, because the *now absolute* has nothing to do with the past or the future. The same general notion, as to Space, is to a certain extent conveyed by the word "here," although "here," when applied to the point, is less expressive of the infinitely minute, because it does not imply that intensity of fixation which is the quality of the present "now."

The *present moment* in Time suggests the ideas of absolute *fixation* and *necessity.* The idea of *motion in connexion with it,* is a cause of its *annihilation: if it moves, it ceases to be the present:* if it be the past, it ceases to exist: and yet paradoxical as such a notion seems, its existence is the real but unsubstantial type of an *infinite shortness, between which and nonentity, human reason cannot define the difference.*

The mathematical point in Space is not less the type of the infinitely minute, but it may be "*anywhere,*" in infinite Space, and it is capable of being moved in any direction, without the least change of character. It is certain, that there can be only one single instant in relation to the idea of "now" throughout the universe. But the imagined point

(*c*) Institutes of Menu. B. 1, v. 64.

in Space may be multiplied indefinitely, at the pleasure of the imagination: yet this idea of exclusive solitude in connexion with the present moment (which is the exact contrary of that of an infinite multitude) is not the same idea as that of a single universe, or of universality: it is the notion of the existence of an infinitely minute but solitary individual, equally opposed to that of the infinitely vast and all-containing spacial whole, and to the idea of an infinite multiplicity of such units or distinct things, as points in Space. A mathematical point is as much a type of separate individuality as the present instant in time is; but it has an attribute in its infinite capability of being multiplied, which does not belong to the idea expressed by the word "now."

Thus we find, that although these two unsubstantial realisations of the infinitely minute, are of the same division, when opposed to those infinitely vast objects of our thought, which we call Time and Space; yet they are each other's opposites or contraries in reference to their respective attributes.

No effort of our imagination can conceive the possibility of the same moment being the past and future while *it is* the present. "Here," "there," "everywhere," or the *locus in quo* of the *point* in Space, is the type of *liberty*, of something having the quality of being moved, and of the *multiplicity* of similar things, as regards our imaginative powers. "Here" may be "there;" and "there" may be "here," at the pleasure of the imagination; but "*the past*" *can never again be* "*now.*" Yet there is a connection between the present moment and the mathematical point, when the *passing* characteristic of the present is considered in relation to the past and future, which suggests the crowning paradox of "*being and not being*," as regards time.

Being, existing, progression, and activity, are all in the imagination, when the *passing* moment is the object of deep meditation; but all ideas of action or even of identity, must be connected with the abstract notion of a *continuousness* in time. "Now," or the present moment, in its fixed character, which corresponds with that of the sentiment, "I am," suggests no idea of identity or of continued sameness; unless it be considered the passing moment, as well as the present, it is wholly isolated.

But as the present must pass, it is possible to conceive the combination of the past or future with the absolutely existing present, and to entertain the complicated idea of an identical something at rest, but still *potentially* endued with the faculty of motion; although such a complication is illusory and contrary to fact as regards either the present or passing moment, because there is nothing *in the relations* of Time, which implies rest, unless it be found in the accidental limits of a beginning and an end, which bound a period of Time. Still the idea is suggested by our meditations upon the popular notion of duration: this seems to invest the *evanescent present* with an attribute of identity like that of the mathematical point, which may be either at rest, or in motion: hence arises the erroneous conclusion, that there can be a strictly logical relation between the *passing moment* and the *mathematical point*, in the idea of continued existence. A more complicated semblance of a connexion between the *passing* moment and the *moving* point (as regards the general idea of the same entity being subject both to *temporal* and *spacial* laws) suggests another incomplete abstract type of a *material body* moving in Space.

But even without reference to Space, we may illogically suppose the identical *passing* moment to be as distinct, during its entire career through the past and future, as it is in its character of the *present* moment. This conception, (as regards psychological doctrines,) would suggest the type of an *immaterial* entity possessing that attribute of *identity*, which is the characteristic of the movable point, independently of the mathematical necessity which implies a position in some *defined* locality in Space, when the point is at rest.

Our simplest notion of *self* and its energy, is typified by this incorrect idea of the present *passing* moment. When such an idea is referred to the sentiment of "I am," it is consistent with the argument to affirm,—that the soul is an essentially active principle, independent of Space, *but not independent of Time, so far as its activity is concerned;* but that it is neither dependent upon Space nor upon Time, when considered in relation to the mere paradoxical present moment, without any idea of its *passing* from the past into the future.

Nevertheless, our notion of the soul, without the attribute of identity, holds an analogy to that of simultaneously "being and not being," which is suggested by the absolute present moment; its nature under that condition is wholly incomprehensible and inexplicable by any process of human logic. The limit between the comprehensible and the incomprehensible worlds is clearly defined in this instance, where there is a confusion in our ideas of a beginning and an end in Time, and consequently of the duration of a period of time. Thus our most refined ideas of personal *being* appear to be based upon that of individual momentary existence; but those of personal *identity* are connected with that of *duration*, which is a relation of a complicated character, involving in its analysis the consideration of the past and future.

Duration, in the abstract, may be viewed as the connecting link in metaphysics, between our ideas of absolute Time and of the present moment,—the two most simple types of imaginable contrariety. All ideas of life and death, or of beginning and end, are connected with that of duration; and even if we had no other grounds for maintaining, that absolute Time is not the same thing as duration, but an idea *sui generis*, this argument would be conclusive. Human experience, however, induces an impression that "living" and "being" are identical; and in our ordinary meditations, we do not define the appropriate distinctions between *present* existence, existence *for a period*, and *eternal* existence, which would indicate three totally different modes of considering *individuality* in connexion with the separate ideas of "now," of "duration," and of absolute "Time," or eternity.

Such remarks may appear too sophistical, or at all events too dialectical, to naturalists whose attention is wholly devoted to the observation of phenomena and the inferences deduced from them, as well as to those mechanicians who, discountenancing any attempt to connect metaphysics and mathematics, apply the term of *idealism* to any mode of argument which is less limited than their own. The method suggested in the present essay, renders it necessary to extend the analysis of all our ideas about *motion* to ultimate elements, and to ponder deeply upon certain doctrines about Time and Space, which have seriously tended to curtail the legitimate exercise of human reason.

It has been alleged by some objectors to the theory of "gradual development," that its supporters have no starting point or elementary basis upon which they can found their assumptions. In answer to such criticisms, it is now proposed to demonstrate, that even as regards forms and numbers in the abstract, there is a gradually developed system of progression, in which the complicated idea is self-suggested by the more simple, under certain obvious conditions of varied motion: but in pursuance of this method of reasoning, it becomes requisite to touch upon questions which have more or less occupied the attention of every metaphysician, and not only to search for the elementary principles of the material world in the abstract laws of mathematics, but to trace up the mathematical elements themselves to metaphysics, where *informal ideas* are the counterparts of physical phenomena and of our ideas of form.

This mode of argument does not necessarily lead to psychological disquisitions, although the same elementary basis may suffice for a superstructure either of material or of metaphysical philosophy.

SECTION IV.

On the gradual and self-suggested development of our ideas of form.

The hypothesis of some geological naturalists, that the original ancestors of the highest animals or vegetables now inhabiting the surface of this planet, were beings of the most simple structure, coincides with the incontrovertible theory of the mathematician, who demonstrates,—that the most complicated forms can be deduced, in a regular succession, from the most elementary, by a process which may be critically termed one of generation.

It is well-known, that by attributing a rotatory motion to a straight line, we may conceive the formal idea of a circle, and that by again applying motion as an elementary principle to the circular circumferential line thus generated (while we suppose the original line to be its axis diameter at rest within it) we may construct the outline of a sphere. But the ellipse, the parabola, and the hyperbola, may, in like manner, be generated *without the aid of a cone*, if we consider *motion* as a constant elementary principle, or (if it may be so called) a vivifying influence, which is to be applied to two circles in opposite methods, but according to a regular system of *contrariety* as regards the mode of its application.

This self-suggested development of a constantly increasing complication in the generation of new mathematical figures, is based upon the earlier ideas of *two points* in Space,—of *motion* in relation to the limited distance between them,—and of *contrariety* in the abstract, both in respect to the direction of the imaginary movement, and to the parts of any parent figure, which are affected by it.

But it has been already shown, that the idea of motion in the abstract may be referred to the inevitable progression of the *passing* moment, and that the idea of the passing moment may be reduced by metaphysical analysis to the ultimate elements of the *present* moment and of absolute or *infinite Time*, when they are brought into ideal relation with each other, by meditating upon our most abstract notion of *duration*.

The mathematical point, however, is incapable of any such analysis, for it is the representative of the infinitely minute; it may, therefore, be treated as an ultimate element in our abstract mathematical speculations: but any spacial region in which points may be supposed to move, is so far the analogue of duration, that, in its character of extension, it may be analysed and referred to the motion of the points, or to the distance between points, or to lines determined by points, or to figures composed of such lines. Still all such formal ideas, including that of distance in the abstract, are dependent upon our all-including idea of absolute Space, which is like eternal Time, an universal medium or elementary principle incapable of analysis, in regard to its infinite character.

Hence we may satisfy ourselves, that Time and Space (as universals), the present moment, and the mathematical point, (as individuals) are the four ultimate elements of all ideas of form, and even of that of *locomotion* in the abstract. When we proceed to the synthesis of all these ultimate elements, we imagine the development of a system, in which the application of *ideal motion, as a generative power*, to any existing mathematical form, will be productive of a new and higher form.

This improving progression will be typical not only of the generation of new individuals of a species, but of new species of a genus (for the same mathematical process will simultaneously suggest the ideas of a distinct second circle, and of an ellipse, as will be shown presently),—and the scheme may be applied, not only analogically but practically, to material processes of physical reproduction, and to the improvement of a specific series, as regards chemistry, botany, and zoology.

In subsequent parts of the treatise, this general notion will be adverted to, as occasion may require; and it will be explained, that the form of each individual atom in the material world, and of every distinct corpuscule composed of atoms,—the various physical qualities resulting from atomic or molecular combination,—the physiological laws of vegetable and animal life,—and even the mental faculties of all animal bodies,—appear to be the consequences of *materialising* a succession of ideas, which may be all reduced to our primary elementary notions about Time, Space, the present moment, and the mathematical point. But as a *substantial basis* is necessary to the physical manifestation of such a scheme of progressive development, we must commence our inquiries with the postulate,—that *inert passive matter* is under the control of the great *immaterial mind*,—and we must suppose that both one and the other of these elementary essences hold no relation to our ideas of a beginning and an end.

In subsequent essays it will be shown, that the idea of a series of primary numbers is the inevitable adjunct and counterpart of that of a series of abstract forms which are thus self-generated in our minds; and that such a numerical progression is the basis of a completely harmonious system of numerical proportions, which like that of the ideal forms, has influenced the manifestation of all material phenomena.

Before, however, we proceed to the discovery of these numerical truths, let us consider the self-suggested mode of deducing our successive ideas of the circle, the sphere, the ellipse, the parabola, and the hyperbola, from our simplest mathematical elements.

SECTION V.

On the ideal generation of the Circle.

WITH universal space as an axiomatic medium, we find no more difficulty in conceiving the notion of a point within it, than in an ocean or a desert. Like many other ideas, that of a point in space may have been suggested originally to our thoughts by the experience of our senses, in connexion with matter; but the idea is so nearly one of abstraction, that the youngest mathematical student breaks the connexion in his own mind, as if by instinct: all he requires is space, and in that infinite void he places his first ideal point where he pleases.

His notion of a second point immediately suggests those of limits and boundaries,—of *beginning* and *end*, as well as of *distance*: the single point is independent of all such accompanying ideas, and unless we suppose the existence of a second point, a solitary point is like the *present moment* in time, an emblem of absolute one-ness. The second point, however, can only be imagined as an independent ideal entity, which claims equal consideration with the first point, in all that regards the formal or mathematical conceptions of the human mind.

Hence we may determine that DUALITY *is a quantitative basis of all abstract ideas of form*; *distance* is the *first relation* suggested by the two points, and the imaginary *straight line* between them is the *first idea of form*, in which that of distance is made manifest: the notion of *length* in the abstract is thus obtained.

Next in succession in the natural order of *formal* ideas, is that which arises from *motion* being considered in relation either to one or both points, or to the two ends of the line connecting them, which is absolutely and permanently straight (according to the conditions of its own creation), and of an unchangeable length. Whether one end of the line be supposed to *move*, while the *other* is fixed or *at rest*—or *both points*, thus connected, be supposed to *move* in *opposite directions*,—the formal consequence in either case, is the creation of an ideal circle, which conveys the notion of a completely bounded region in space, although it is the simplest of all superficial figures.

We may thus attain the idea of an uniform enclosure in space by meditating.

1st. On the *infinitely vast* and *infinitely minute*, as regards space and the point in space.

2dly. On the idea of *distance*, or *length without width or depth*, in relation to mathematical duality, as regards the *line*.

3dly. On the idea of *motion* or action, in opposition to *rest* or inaction, as regards the construction of the circle.

The existence of matter does not occur to the mind during the process; and although the simple mathematical laws which are developed in the construction of ideal superficial figures, only constitute a small portion of the entire system of those formal regulations which govern matter, while other laws are necessary to the manifestation of that system,—yet a superficial circle, which is an important and complete mathematical figure, presents itself to the human mind, not in consequence of our experience in dealing with *material* forms, but under imagined simple conditions of mathematical certainty, which are as satisfactory as if the circular figure had been represented to the sense of sight or touch.

It follows, therefore, that human intelligence has the power of generating ideas in connexion with its own immaterial notions of infinite vastness and minuteness, of motion and rest,—and that the idea of space itself and of formal images contained within it, does not depend upon that of matter, *because* the abstract *superficial circle has no depth*, and we cannot conceive the possibility of matter existing, unless it has thickness or depth as well as length and width.

SECTION VI.

On the generation of the ideas of two semicircles and of a sphere.

WHEN the idea of the formal circle is complete, and the imaginary line is supposed to be at rest, a new notion of form is presented to the mind: two semicircles are created, and the first type of a *division* of a limited spacial region becomes manifest. This step in the progression depends upon the development of an *antagonism* of conditions; because it is necessary that the diametrical line or the formalised distance between two points should change its state from one of motion to one of rest, in order to create the image of a bisected circle.

If we imagine another sort of antagonism, and *transfer the motive energy from the diameter to the newly created circumference of the circle*, without attributing change of place to the whole figure, the only conceivable manifestation of motion will be the rotation of the circumferential line upon the quiescent diameter as upon an axis. Since the formal result of this change will be the development of an *ideal sphere*, having its poles and an equator,—all points which are upon different circles of latitude in one of its hemispheres will move with a different degree of locomotive rapidity during the rotation. Hence a much more complicated idea of motion will be formalised by this process, than by that of the revolution of a straight line upon its central point.

The above method of accounting for the generation of the circle and the sphere, is very ancient. In the "Timæus" of Plato, we find that the cosmogony of the Pythagoreans was based upon the idea of a straight line revolving upon its centre, and elsewhere the whole image of the universe itself was referred to the circumference of a circle rotating upon the diameter. The Greek cosmogonists, however, who adopted this mode of argument, generally fell into the illogical error of supposing, that *infinite* space had the formal qualities of a sphere, or of a mathematical figure which was *bounded* in every direction.

There is no evidence to prove that the *physical* philosophy of Pythagoras himself was exempt from this inconsistency; Anaximander, the disciple of Thales, taught the same doctrine; and the firm hold of the Ptolemaic system upon the human mind until a comparatively modern period, proves that although some of the ancient astronomers may have believed the Earth to be a subordinate heavenly body, the majority entertained the opinion that our planet was the centre of the spacial expanse, and that the Heavens had a definite boundary.

That such an error should have prevailed is extraordinary, considering the assiduity with which the ancient mathematicians studied elementary principles, and analysed their most apparently simple ideas of form and number in the abstract. The first conclusion of any reflecting mind capable of thinking for itself, must have been,—that Space as a whole is boundless. Applying this axiom to any cosmical theory, it seems surprising, that most of the ancient astronomers should have been blind to the inference,—that as ideas of a centre and a circumference can only be relative to an ideal point, and to a limited distance from it, there can be no ultimate boundary where the distance is infinite, even if the assumed central point be admitted to have such a fixed locality in Space, as that of the Earth in the system of Ptolemy.

SECTION VII.

On the simplest mode of generating the idea of two concentric and equal circles which occupy the same area.

In accordance with our general rule of only employing previously-generated mathematical elements as the *substantiale* of any new mathematical figure, and of imagining the development of such a figure in consequence of some novel method of applying *motion* to these elements, we are precluded from adopting any artificial device, such as that of constructing a new circle by *copying* one already accounted for.

It is evident, that in the preceding method of producing a circle by attributing an antagonistic motion to the two ends of a limited straight line, or to the two points which constitute its *termini*, the circumference of the circle will have been completely described as soon as the line in question has made *half a revolution* on its *medial* point, because each of its *terminal* points will then have replaced the other, and each of these points will have traced the respective semi-circumferences of one whole circle.

If, however, we suppose a limited straight line to have made an *entire* revolution, each of its *terminal* points must have returned to its original place, and will have described a complete circle instead of the semi-circumference of a circle. The general result will be the *ideal* development of *two* circular figures, but *they will only appear to be one;* and both circles will seem to be identically the same, because they will have a common centre, and the path of one revolving point will be upon the line already determined by the other.

These two ideal circles, however, will have been generated in different intervals of time, and they will hold relations of *seniority* to each other, as regards the period of their development. The *first* circle will have been delineated during the first half of the operation, and the process of its formation will have been concluded when the two moving *terminal* points of the line have replaced each other. The commencement of the *second* circle's delineation will be coincident with the passage of one of the terminal points over the place or site of the other, and with its beginning to return from that place to its own original site.

Considered as a problem in relation to space and time, this is of great importance, because it demonstrates that ideal mathematical figures which are perfectly identical in regard to space itself, or *the medium of locality*, may be quite distinct from each other in regard to time, or *the medium of activity*; and we thus attain an idea of a distinct individuality, even with respect to spacial delineation, without being obliged to admit that a formal occupation of any given region in space by a mathematical figure, precludes the possibility of its being simultaneously occupied by another distinct individual. The law of physics, which determines that the plenary occupation of a given region in space by *matter* must be *exclusive*, does not apply to *ideal* mathematical forms. A vast multitude of concentric and equal circles may be supposed to be individually distinct from each other, in our recollection of such ideals, although they may occupy the same identical locality as if they were only one circle. Their individuality is not demonstrable to the senses in such a case; but it is proved by the more certain test of successive processes, during which they are generated in a series of ideal operations, and on account of which they may be understood to hold relations of *precedence* and *subsequence* to each other. These relations cannot be supposed to exist, except as attributes of distinct individuals.

When we apply the same mode of reasoning to the idea of the generation of a sphere, we find that the above truth is still more obvious: because a sphere is a perfect enclosure of space, having the qualities of length, width, and *thickness*, while a superficial circle has only the two attributes of length and width.

The transfer of the *motive* principle from the diametrical to the circumferential line of the circle, supposes, that instead of the diameter being in motion, it is at rest, and that the *lateral path* of the circle's circumference describes the whole spherical outline. But the process of delineation in this case is a *double one,* as it is in the instance of the two terminal points of the rotating diameter.

One ideal figure of a sphere is complete as soon as the two semi-circumferential lines of the circle have exchanged places, and a *second* such figure is imaged as soon as these lines return, in their lateral sweep, to their original localities.

Hence we have the idea of two identical spheres, whose length, width, and depth are exactly alike, occupying the same area,—an impossible condition in physics, but one which is perfectly comprehensible in theoretical mathematics, when we ponder upon the problem as has been done in regard to ideal circles, and when we look to the process of generating the two spheres *in relation to successive periods of time.* Physically, we are precluded from supposing that two concentric spheres could occupy the same area, unless they were one within the other, and the outer sphere were hollow; in that case, the inner sphere must be smaller than that which is external.[d]

The diagram, figure 3, plate 1, demonstrates the two-fold process of a simultaneous formation of two connected semicircles, in consequence of the two terminal points of a diametrical straight line changing their places.

[d] It will be found that this general geometrical truth is very important in the arithmetical system which may deduced from our ideas of form, and more particularly in the *logarithmic* relations of numbers which depend upon such a system; because it will account for the single circle being represented in numbers by a fraction of an integral number, instead of the integral unit itself. This result is demonstrated in page 66 of the treatise on *formally-originated* numbers, to which the present essay upon the self-development of our formal ideas may be considered as an introduction.

SECTION VIII.

On the self-development of the ideas of two connected circles having distinct areas, of the ellipse, and of the collapse of a circle upon its diameter.

Having thus succeeded in accounting for the self-development of the idea of two *concentric circles*, which are *apparently* only one, because they occupy the same area,—let us suppose that the principle of motion is applied to both of them in such a way, that the one slides off laterally from the other, so as to account for the gradual divergence of their centres from the common point of concentricity, and consequently for the *manifestation* of two distinct circular areas. This method of considering motion in relation to *an entire circle*, is an advance in the general scheme of applying it to our previously-attained ideas of form, as the diameter and circumference of a circle have only been hitherto imagined to be separately in motion, the diameter alone being supposed to be moving in one case, and the circumference in the other, while the diameter was at rest.

In thus applying motion to two entire circles, we are still precluded from supposing that the movement can effect the complete disjunction of the two circular concentric rings, because the given element of only one diameter common to both circles, does not admit of our extending the diverging motion of their *centres* beyond the two *terminal* points of the original straight line. It will be found that when the two centres are supposed to move in opposite directions upon the original diameter, and to *cease from moving* when they have arrived at its *terminal* points, the two circles will occupy perfectly distinct areas, but that their circumferences will be in contact at that point of the line, which was their common centre before the commencement of their divergent motion.

By this simple operation we attain the idea of a figure consisting of two equal circles in contact with each other, without having had recourse to any artificial method of copying one of them from the other; but the most important result of the centres of the circles being in motion, is the self-suggestion of the elements of the elliptic form in all its varieties of eccentricity, which is a mathematical phenomenon of the same self-developing character as the manifestation of the circle, or of the sphere, described in preceding sections; while it is a far more complicated deduction, because it creates the idea of a *continuous change in the outline* of a completely bounded elliptical area.

The elements of the ellipse thus produced differ, at first, in the slightest possible degree from those of a circle; but it becomes more and more eccentric, and finally collapses upon, and appears to be identical with, the original straight line, which was the basis of the circle, the sphere, and the ellipse itself, and is the only given formal element in our gradually developed scheme of generating one form from another by a regular method of applying *the principle of motion*, according to the most obvious method of so doing.

When we reverse the process, and suppose that two equal but distinct circular areas *converge* into one, we shall find, that as the generation of the idea of two distinct circles out of one circular area, suggests that of a complete *collapse* of a third circle upon its diameter, through the intervention of a variable ellipse,—the reversed process (namely, that which moves the centres of two distinct circles to the point of contact on their circumferences and makes them concentric) will suggest the idea of the same straight line, *swelling out* laterally in an elliptic form, and thus at last regenerating the idea of the original circle, which will be the vanishing form of the expanding elliptical area, when its transverse axis is a constant length, during the continuous change of its eccentricity.

It is possible to combine both these processes, and to treat them as one continued operation, if we suppose two distinct but connected circular areas to change places, one passing over the other. In that case, the line connecting their centres will gradually *decrease* to a point, and then gradually *increase* to its original length; while the contingent ellipse will be developed, first, as a straight line, *expanding* elliptically, until it offers the area of a circle, and subsequently *collapsing*, until it is merged in the same line, which had been its transverse axis during the whole operation, and was our original formal element, whose rotation suggested the first idea of the circle.

The most obvious principle, or test, of an elliptic area, is perfectly exhibited in this mode of accounting for the generation of its curve, which does not happen when it is produced by the intersection of a plane and a curve.

The principle in question is, that any two lines on the same side of the ellipse, which describe the distances between both its *foci* and *any common point on that side of its bounding curve*, should be *together* equal to its transverse axis. If *one* of these lines be *shorter* than one-half of the transverse axis, the *increase* in the length of *the other* will be equal to that difference.

Now, as the four principal points in the general figure of two intersecting circles are the two centres of such circles, and the two points at which they intersect each other,—it is evident, that if the centres be supposed to represent the *foci* of an ellipse, the two points at which the circles intersect each other, will represent *the two ends of its conjugate*, while the two radii of the intersecting circles, which meet at that point, will meet upon the elliptic curve itself. We have therefore visible elements in this figure, which are not only sufficient for the construction of the ellipse, but which determine its limits. Although the *elliptic curve* itself is not described by the motion of the circles, we observe the gradual diminution of the *conjugate*, and the gradual divergence of its *foci*, which are the elements of a still more interesting phenomenon than the construction of a fixed ellipse, namely, the manifestation of the *elements* of every possible eccentricity of an ellipse in a continuous process of self-development.

In conclusion, it may be remarked, that the following notable harmonies exist between the ellipse and either of its parent circles, when it is constructed in accordance with the above method.

1. When the two foci of an ellipse are concentrated, its area is converted into that of a circle.

2. When the two foci of the ellipse are removed to their greatest possible distance from each other, upon its *transverse axis*, the area vanishes in the diameter of that of the circle.

Exemplification.

Let the circles ABCE and FEDB, in the figures 1 and 2 of plate 1, be the two intersecting circles in different stages of their variable relation to each other.

Their *centres* K and I will be the *foci* of the ellipse GBHE; and the points of intersection B and E will be the ends of the *conjugate* of the ellipse in both cases. The original *diameter* of the circular area, from which both the moving circles have emanated, will be equal to GH, the *transverse axis* of the ellipse in all its varieties of eccentricity.

The two lines KB and IB will be converging radii of the two circles; they are together equal to KL and IL, which are together equal to GH, the transverse axis of the ellipse. This rule of proportion will hold good at any point upon the elliptic curve GBHE, which will determine the variable increase and corresponding decrease of any two converging lines drawn from the respective foci of the ellipse, provided these two lines are together equal to the transverse axis of the ellipse, or to two radii of either of the intersecting circles.

The dotted line GMHN indicates the area originally occupied by the two equal concentric circles, and it will be seen that the diameter of that area is identical with the transverse axis of the ellipse in both figures.

As the circles in both figures are equal to each other, the ellipses in both exhibit different stages of the collapse of a variable area, whose mode of change and all whose other formal qualities are delineated *automatically* during the process.

SECTION IX.

On the self-development of the idea of a uniform expansion of a circular area, and its application to the preceding method of generating the elements of an ellipse.

In the foregoing section, we have accounted for the idea of an increasing straight line; the centres of the circles are supposed to move upon the original diameter, *rectilinearly*, until they reach the circumference of the original area, and their two diameters constitute one straight line, equal to twice that original diameter, when the circles themselves occupy distinct areas.

As their motion is assumed to be gradual, the increase of the length of their common diameter must also be gradual; therefore by fixing upon any stage of the operation, we may attain the idea of any straight line which is greater than the original diameter, but not greater than the double of that diameter, beyond which length the common diameter cannot be increased in this process, because the two circles, although occupying distinct areas, are still supposed to be in contact at the end of the operation.

If we repeat the process of applying a rotatory motion to the increasing straight line, at any stage of its increase, or suppose *that it may be rotating during its increase*, the idea of a uniformly expanding circle is suggested to the imagination. Should the rotation be upon its medial point, the ultimate

PLATE I.

Fig. 3.

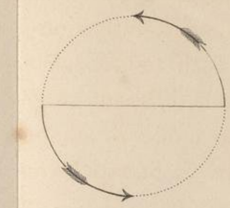


Fig. 1.

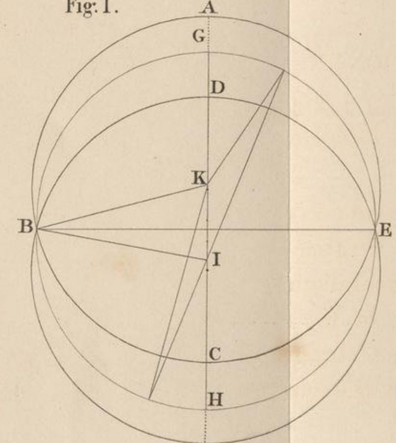


Fig. 2.

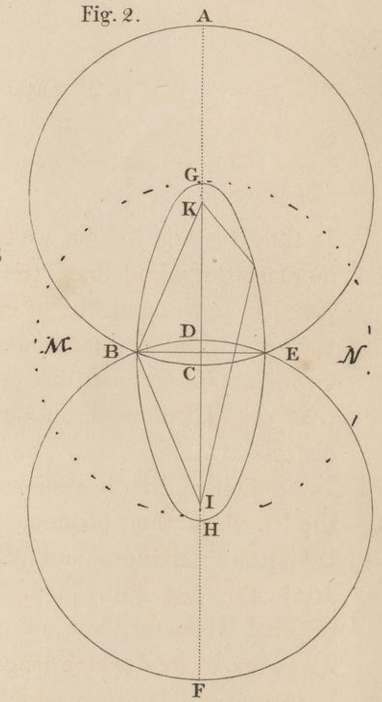
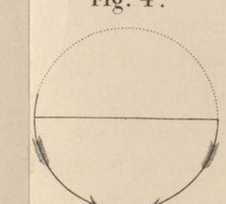


Fig. 4.



limit of the expansion can only lead to the generation of a circle whose diameter will, at most, be equal to *two* diameters of the original area. Should the rotation of the line be upon one of its terminal points, the expansion may ultimately extend the increasing circular area, until its diameter equals *four* diameters of the original circle.

Now having attained the idea of this gradual, but limited, expansibility of an original circle, we are enabled to imagine the combined process of two equal concentric circles, diverging from each other until they occupy distinct areas, but *expanding* equally during their divergence, until each of their diameters is double that of the original area. We may also imagine the opposite process of their contraction from that size to the original size, while they converge to their concentricity.

This more complicated idea of change must have its effect upon the elements of the variable ellipse, which would be determined by the alteration of the localities occupied by their moving centres and their moving points of intersection. The four points in question would at any moment represent the *foci* and the two *ends of the minor axis* of an ellipse ; but the varying attributes of the ellipse under these conditions, would not be the same as if the generating circles underwent no such increase or decrease of their areas.

The most important consequence of their expansion or contraction, would be the continuous alteration *in both the axes* of the changing ellipse. The major or transverse axis would be lengthened, as the minor axis or conjugate was becoming shorter, during the expansion and divergence of the generating circles; and in the opposite process, the transverse axis would be shortened, while the conjugate was becoming longer, during the contraction and convergence of the circles.

When the diverging or converging circles undergo no change, the transverse axis is constantly of the same length, whatever may be the stage of the varying eccentricity of the ellipse; and, it has been already observed, that *that* length must be the same as that of the diameter of the original area in which the equal generating circles were concentric.

We have thus advanced in our idea of the elements of an ellipse which undergoes a change in its eccentricity, by *getting rid of the constant quantity implied in the length of its transverse axis.* We shall find that the idea of a fixed quantity will, in such a case, have been transferred *from the diameter* to the *outline*, a most important discovery as regards the application of the laws of the ellipse to practical physics.

Before, however, we attempt to demonstate this, let us endeavour to deduce our *outline* of a *non-circular* curve itself, instead of the elements of such a curve, from the formal data already generated.

SECTION X.

On the self-development of a non-circular curve, which is delineated by the moving centre of an expanding circle, when its circumference is in contact with that of another circle during the process of its expansion.

As our idea of a circle described by the *complete* revolution of the diameter upon its medial point, is that of two concentric rings occupying the same area, and we have already supposed, in the last section, that each of the diameters may rotate during the divergence or convergence of these two distinct circles,—we find no difficulty in accounting for each of them holding an analogy to the original area, in being double, when they occupy their distinct areas, and are in contact *circumferentially*, instead of being concentric.

We may therefore assume, that each of these distinct areas consists of two equal concentric circles, which are capable of diverging from their respective common centres in a rectilinear direction. The result of this operation (supposing the second divergence was upon the joint diameter) would be, that one circle of each pair would return to the original single area, while the other of each pair would diverge in the opposite direction, exhibiting three areas upon a common axis which would equal three original diameters.

But if we assume, that the secondary divergence takes place upon a diameter, which is at right angles to the original axis, the result would be a square of *four* equal circles, when the secondary divergence was complete, provided there had been no coincidental expansion of their areas during the process. The two original circles would not intersect each other in such a case, and the *points* of *contact* between the circumferences of their respective offspring, would also *move* in two opposite directions *upon the same straight line.*

Now supposing that all four circles *expanded equally*, while the secondary diverging motion occurred, and that the two *moving points of contact*, between the circumferences of the opposite pairs, described the same straight line as they would do, when the areas do not expand,—it is evident that the *centres* of all the four expanding areas, must move in a *curved line*, which may be proved to be that of a *parabola.* Each opposite pair would describe an opposite parabola, and the *rectilinear path of their moving points of contact would be the directrix common to both these parabolic curves:* in other words, each pair of circles would *direct* the centres of the other (whatever might be the rate of their expansion) in a *parabolic* curve,—provided they expanded in equal proportions, and the two circles of each pair were constantly in contact with each other at the respective ends of the diameter which is common to the two original areas. Those points would be the *foci* of the two parabolas, while the two *original centres* from which the centres of the new pairs would diverge, would be the *principal vertices* of the parabolas.

If we suppose, as another condition, that one of the original circles undergoes no change, while the other divides into two diverging and *expanding* areas, which are always in contact with each other circumferentially at the same point, (the end of the diameter of their parent area), while they are also circumferentially in contact with the outline of the other unchangeable original circle,—it is evident that the point at which they are in contact with that circle would be a moveable one, and that it must describe an arc of that circle itself. Their *centres*, however, in consequence of their *expansion*, would describe a *non-circular* curve, which must be that of a *hyperbola*. The same fixed point of contact on the circumferences of the delineating circles, would nevertheless be the *focus* of the hyperbola and parabola in both cases, and it would always be upon the hyperbolic *latus rectum* and the parabolic *conjugate*. In the case of the *hyperbola*, the guide of the expanding, and delineating pair of circles, as regards the hyperbolic curve described by their moving centres, would be the original unchanged and apparently single circle, which may be termed the *directing* circle, while the other pair might, with equal propriety, be called the parent circles.

Again, let us suppose, as a third condition, that both the original circles do not divide into two pairs, but that one of them only produces the two expanding areas, while the other expands *in situ* as a single circle; and that its *expanding* circumference controls the motion of the delineating centres of the other's offspring, in the same way as the *non-expanding* area does in the case of the hyperbola.

This condition of the *directing* circle will occasion the motion of the centres of the *delineating* circles to be upon an *elliptic* curve; provided those delineating circles be always circumferentially in contact with each other at the same fixed point, as in the cases of the parabola and hyperbola,—and that whatever may be the rate of their expansion, and the eccentricity of the consequent ellipse, that point be one of its *foci*.

In thus accounting for the self-development of the parabolic, hyperbolic, and elliptic curves, we may either suppose that the motion of the two circles whose centres describe them, would have been a *rectilinear* divergence from a common area, had they not been pushed, as it were, from their straight path by the interference of the *directing* circle's circumference acting upon their own expanding outlines,—or, that in all three cases, they *rotate* upon the fixed point of contact, which is the focus, but that the rotation is interfered with, by the necessity for their being also in contact with the circumference of the directing circle.

The idea of the *rectilinear* movement of the diverging centres being interfered with by an external force, is best suited to the process which occasions the delineation of the *parabolic curves,* but that of the movement of the delineating circles being one of *rotation* upon a common pivot, seems more applicable to the operation by which the *elliptic* curve is generated, because the delineating circles converge as soon as their centres are at each end of the conjugate of the ellipse, and eventually meet in a common area, when their centres unite at the opposite vertex and the whole outline of the ellipse has been described.

Let us now proceed to the details of these important problems, and satisfy ourselves that the ideas of the three great curves of the conic sections are thus simply and easily accounted for, in a scheme of self-development.

SECTION XI.

On the generation of the parabolic curve when it is described by the moving centres of expanding circles.

When we deduce the parabola from the motion of the *centres* of expanding circles which diverge from a common area in opposite directions, the two equal lines which connect any point in the curve with the *focus* and with the nearest point in the *directrix*, are obviously represented by two radii of the same circle. But the development of the rectilinear directrix itself, occurs *simultaneously* with that of the curve, in this method of accounting for a parabola.

It has been already affirmed, that in deriving the complete parabola from circles, we must suppose each of the two original areas to undergo the same process of subdivision, and that *four* new circles are generated from them, which diverge and expand under similar conditions and in the same proportions. We shall then find that the moving points of contact between the circumferences of corresponding circles belonging to opposite pairs, will each describe equal lengths of the same straight line in opposite directions, their point of departure being that at which the original circles were in contact before the commencement of the present process.

This one straight line being the common directrix of two opposite parabolas, the ratio of its extension will always be determined by the coincident expansion of the four equal circles, of which it is both the offspring and the guide ; and its development will be the manifestation of our first idea of an illimitably extensible straight line.

Exemplification.

Let BFC and CED be the two equal circles in contact, having their centres at A and Z. Plate 2.

Let DOX on the right hand of the figure be a temporary arc of one of the expanding rings which emanate from CED, and rotate upon D. Its centre will be at E, and ED will of course be equal to EO.

Let BOV be the segment of the corresponding ring which has emanated from BFC rotating upon B. Its centre will be at F, and FB will be equal to FO. The two centres of the expanding circles will have moved in the corresponding, but opposite parabolic curves ZE and AF, and the point of contact between the expanding and rotating circles will have moved rectilinearly from C to O.

Let us next suppose another stage of their expansion and rotation when their centres are at X and V, and their areas are represented by the segments DGI and BGK. It will be found that, according to the rate of expansion assumed in this diagram, when the centres have moved down to the lines NX and YV, and they are upon the conjugate or minor axis of the parabola, the circles will have increased by one whole diameter, or will have been doubled ; for DI is equal to DB.

SECTION XII.

On the generation of the hyperbolic curve, when it is described by the moving centres of two expanding circles.

THE main principle of the hyperbola is defined in the following proposition. If two lines be drawn from any point upon a *hyperbolic* curve, the one to a given point *within* the curve, the other to a given point *without* and above it, (both such given points being upon its major axis), the *difference* in the length of these two lines is equal to the difference between any other two lines, which may both be drawn from *any other* point of the curve to these same given points.

This principle is perfectly demonstrated in our method of constructing the hyperbola, while the *radius* of the same unchanging circle is the *measure of the constant difference* in question. Its circumference must cut off a portion from the line which connects its centre (the *external* given point) with the centre of the expanding circle. The remaining portion will be one of the radii of the expanding circle, while the other line, which connects its centre with the internal given point, is another of its radii. The increase of both lines must be determined by that of the *expanding* circle ; and the point at which the expanding and non-expanding, or the generating and directing, circles are in contact with each other at any stage of the expansion, will be at the same distance from the portion of the curve occupied by the centre of the expanding circle, as that centre is from the *internal focus,* which is at the end of one of its radii.

The circumference of the unchanging circle is therefore the practical *directrix* of the hyperbola in such a case.[e]

Hence it is evident, that the circumference of the fixed circle cuts off a certain *constant* quantity from the *longer* line between the point in the curve, and the *external* focus, leaving a *varying* remainder, which is equal to the *shorter* line drawn from the moveable centre to the *internal* focus, because that line and the *remainder* of the longer one are radii of the same expanded circle.

Not only therefore is the original unchanging circle in our figure the *practical* directing guide of the moving centre of the expanding circles, while the curve itself is being delineated,—but it is the visible *mensurator* of that constant *difference* between the lines connecting the two foci of the hyperbola with any point in its curve, which furnishes us with the main test of its hyperbolic character.[f]

Exemplification.

The general figure, in plate 2, represents the mode of generating both the hyperbola and the parobola by the circular expansion. The hyperbola is the curve on the left of the transverse axis ZD or AB.

[e] The reader must bear in mind, that the term *directrix*, in regard to the *hyperbola*, has been applied by writers on the conic sections, to a *straight* line which cuts its major axis at right angles. This method of assigning such a term to a line which does not correspond with the directrix of the *parabola*, is obviously a mistake; because the counterpart of the *rectilinear* parabolic directrix must be *curvilinear.*

[f] De la Hire's definition of the hyperbola, when he describes it as "a curve, in which *the difference* between two lines, drawn from any point in it to its foci, is equal to its transverse axis,"—is less elementary than that suggested by the above process, although it depends upon a corollary of the proposition, that the difference in question is equal to the radius of the *directing* circle. The *transverse axis* of the hyberbola, or the distance between its vertex and its internal focus, being a radius of the evanescent circular area, from which the expanding circles have emanated, and which was equal to the *directing* circle,—it is evident that *the principle is the same in both methods of definition.*

The original circles are denoted by BFC and CED, whose centres are respectively at A and Z.

The segments of the expanding circle, during the progressive stages of its expansion, are shown at *ab*D, *de*D, and *hi*D, all which circular arcs are in contact with the unchanged original circle BFC in the neighbourhood of *k*. The respective centres of the *expanding* area are thereby directed in the curve Z, *l*, *m*, M, N, which is that of the hyperbola, whose *internal* focus is at D, where all these segments unite, while its *external* focus is at A, the centre of the original non-expanding circle.

The *radius* of the non-expanding circle BFC, will always be equal to the *difference* between two lines drawn from any point in that curve to its two foci A and Z.

Thus A*k* will equal the difference between A*l* and *l*D,—between A*m* and *m*D,—between AM and MD,—and, finally, between AN and ND.

The half of the *latus rectum* is shown at ND, and the point N is the centre of the expanding circle which has reached it.

SECTION XIII.

On the generation of the elliptic curve, when it is described by the moving centres of expanding circles.

Having discovered the directing or controlling influence of one circular area over another, as regards the hyperbola and parabola, let us proceed to apply the same method to the construction of the *ellipse ;* we shall find, that if the original directing circle expand *in situ* without any change in the position of its centre, and without undergoing the splitting or dividing process, which is necessary in the parabola,—its expanding circumferences will direct those of the rotating and expanding circles, in such a path, that their moving centres will describe an elliptic curve.

The only fundamental difference between this process, and that which would guide the centres of the delineating circles in the direction of a *hyperbolic* curve, is, that the *directing* circle remains unchanged in the case of the hyperbola, but that it expands to a limited extent, in that of the ellipse.

But it is evident that the expansion of the directing circle must have a fixed and ultimate limit, whatever may be the eccentricity of the ellipse,—because when the rotating circles have converged to the common area, after their centres have passed the ends of the minor axis of the ellipse, and they meet at the lower vertex, *the point of contact* between *their* new common area and the enlarged area of the *directing* circle, must be the pivot of rotation, which is the upper focus of the ellipse. Therefore the *diameter* of the *directing* circle must always be *ultimately* increased by double the diameter of the other original area, from which the rotating circles emanate.

No such constant and general limitation prevails as a restriction upon the expansibility of the *delineating* circles themselves. We shall find that their expansion may have increased their diameters to any extent, without involving the necessity for any other path being described by their moving centres, than that of any elliptic curve,—provided their circumferences are always in contact with the circumference of the directing circle which expands under the above limitation, of being *ultimately* increased by two diameters, neither more nor less, of the other original area, which is the parent of the two rotating circles.

The basis condition of the whole problem is, that the *radius of the original parent area should be identical with the distance between the vertex and nearest focus of the ellipse.* But the main law which regulates the eccentricity of the ellipse, and determines the harmonious expansion of the *directing* circle, is, that the *ultimate* limit of the directing circle's expansion should be that focus.

In constructing the ellipse according to this method, we are at liberty to assume that the *delineating* circles may have expanded to any extent, by the time their centres have reached the ends of the conjugate. The further extent of their expansion, when the ellipse is completed, will depend upon this assumption; for instance, we shall find, that if the delineating circles have diameters equal to *four* times that of their parent area, when their centres are at each end of the elliptic conjugate,—in other words, if they have been increased by *three* diameters, in that stage of their expansion, they will meet in a common area, the diameter of which will be farther increased by *three* more such original diameters.

But as regards the expansion of the *directing* circle, the variableness of its increase can only apply to the corresponding stages of the *limited quantum of extension,* included between its original outline and the focus of the ellipse, beyond which it cannot pass, for reasons already stated.

Hence it follows, that in constructing the ellipse according to this method, we must determine the varying relations between the directing and the delineating circles, by a more difficult process than in the case of the hyperbola, where the directing circle never changes; or than in that of the parabola, where the simultaneous expansion of the directing and of the delineating circles must be always in equal proportions. In the case of the ellipse, the *rate* of the *delineating* circles' expansion is an optional quantity, which determines the ultimate increase of their diameters when the ellipse is completed; but, as the *ultimate* increase of the *directing* circle is a *fixed quantity,* depending upon the size of the original area from which the generating circles emanate, and as the *whole* increase of the *directing* circle will always be the same, whatever be the assumed rate of the expansion of the generating circles,—the obvious course of proceeding will be, first, to decide upon the rate of the expansion of the delineating circles, and this may be done by fixing upon any optional quantity as the increase of the circles when their centres are on each end of the *minor axis* of the ellipse ; this will give us the elements of the ellipse. Secondly, to describe the corresponding area of the *directing* circle by extending its circumference, until it is in contact with those of the delineating circles when their centres are on the conjugate. This will give the comparative expansion of the *directing* circle, as a *consequence* of the assumed rate of increase of the *delineating* circles ; but it will nevertheless prove that the same principle of *guidance* or *direction* holds good in this instance, as in the case of the hyperbola ; and that it is the influence of the *directing* circle which really determines the *paths* of the centres of the *delineating* circles, although *their* expansion determines the *intermediate distances* between the directing circle's original outline and its fixed ultimate circumference, at which its apparently irregular stages of expansion correspond with the regular succession of increasing diameters in the delineating circles.

Exemplification. Plate 3.

Let the two original circles BCED and EGHF be equal to each other and in contact at E. Then let N be the centre of the delineating circle HVTS at the end of the conjugate ; when its expansion has increased its diameter by *three* times that of its original area EGHF. If the ellipse be described in accordance with this condition, its lower vertex will be at R, which point will be the centre of the circle HX. The diameter of that circle will be *seven* times that of the original area, the increase having enlarged it by *six* original diameters.

This rate of the delineating circle's expansion will have its effect upon the mode in which the *directing* circle will correspond with it.

When the *delineating* circle has expanded to one-half of its ultimate extent in the case under consideration, the *directing* circle will have been already extended to three-fourths of its limited expansibility, measured by diameters. It will thus be seen, that by the time the delineating circle has been increased by *three whole diameters* of its parent area, the directing circle will have expanded by *three half diameters* of that area. Therefore this rate of expansion offers a more obvious harmony than in other cases, although in reality the adjustment in all instances is determined by the same regularly precise law.

As we have sufficient space in this diagram for demonstrating that the path of either of the delineating centres must be upon an elliptic curve, let us determine those points upon the curve which are the respective centres of the delineating circles at different stages of their expansion.

We shall find that when the expansion gives the delineating circle a diameter equal to two diameters of the parent circle, H being the fixed point of rotation, the centre will be at the point L on the curve: in that case the diametrical increase will have been by *one* diameter. When the increase of the area gives three times the original diameter (or, in other words, has been advanced by a second diameter), the moving centre will be at M. It has been already assumed that N is the centre of an area whose diameter is equal to four diameters of the parent area; and it may be shown that the point P is the place of the centre of an area of five such diameters,—that Q is the centre when the area is expanded to six diameters; and that R, the lower vertex of the ellipse, is the common centre of the largest delineating areas on both sides of the ellipse, which have met in the area HVX, where the diameter is equal to seven diameters of the parent circle.

It must be remembered, that in all these cases the original diameter is to be added to the increase, so that when the area is diametrically four or seven times that of the parent circle, the increase has been by three and six diameters respectively. In order to prevent confusion and to obviate the necessity for many letters of notation, the successive areas are numbered 2, 3, 4, 5, 6, 7, the parent circle itself being supposed to be No. 1.

Now, if we wish to describe the corresponding areas of the expanding circle of *direction*, we may do so without difficulty by drawing a series of six concentric circles, whose circumferences must be in contact with those of the corresponding delineating areas. Each area of the expanding circle of *direction* will then appear as the guide of its corresponding area of *delineation ;* and we shall perceive at once that, although the various stages of the apparently irregular expansion of the directing circle during the increase of its diameter from E to H, must depend upon the given rate of regular expansion in the delineating circles, it is *practically* the guide of their centres during their motion from the elliptic vertex I to the opposite vertex R.

Lastly, if we wish to prove that the expanded areas of the delineating circles, *which have their centres at the end of the conjugate,* are the *dominant* areas of the figure, and those which would be equal to the non-expanding circles employed in our first method of determining the elements of the variable ellipse, let us describe two dotted circles having their centres at H and S (the two foci of this ellipse), and their radii equal to the distances between H or S, and N or O the two ends of the conjugate. It is evident that these circles which would have been employed in our *first* method, are each of them equal to HVTS,—the centre of whose area is at N, the end of the conjugate in the present method ; and that they are in that stage of their *non-expanding* divergence from a common area, which would furnish the elements of a variable ellipse, generated by the process described in our eighth section, but in all respects resembling that which is delineated in plate 3. According to this comparison, the area HVTS, in plate 3, which has gone through half its expansion, and not the parent area EGHF, would be the *constant* circle employed in determining the elements of this ellipse, supposing we availed ourselves of the first mode of discovering it with the aid of two *rectilinearly* divergent but *non-expanding* equal circles, whose centres would have moved in opposite directions from W to H and S, and the points of whose intersection would be N and O, when the ellipse, during the change of its eccentricity, had attained that form which is represented in the present diagram.

In this diagram, it has been proved—

1. That the centres of the delineating circles thus *directed* by the circumference of an *expanding* circle, whatever may be their own assumed rate of expansion, must move upon an elliptic curve.

2. That the eccentricity of the ellipse, even when the original circles are equal, may be varied, at pleasure, by assuming that the requisite rate of expansion as regards the *delineating* circles, is an *optional* quantity in the problem, while the *directing* circle can never expand beyond the nearest focus of the ellipse. In this respect the fixed ellipse constructed according to the present method, differs from the parabola and hyperbola, when their curves are delineated in an analogous manner by the moving centres of expanding circles; because, if the original areas be equal to each other, the rate of the delineating circles' expansion will be determined by the relations between their parent area and that of the directing circle, when that circle does not vary during the process, or when it expands at the same rate, as that of the delineating areas.

3. That the apparently irregular divisions of the limited space assigned to the expansion of the *directing* circle, as regards the ellipse, must depend upon the regular rate of expansion of the *delineating* circles.

4. That the extent to which the *delineating* circles have expanded, when their centres are at the two ends of the minor axis or conjugate of the ellipse, is the *mean* of the whole expansion of those circles; and that, therefore, the

dominant area as regards any ellipse, in relation to its elements, which may be determined by the rectilinear divergence of two equal circles, *is not* the *parent* area from whence the delineating circles emanate, but the areas which they exhibit, when they have attained the *mean* of their whole expansion. Such areas are equal to the two equal circles, whose points of intersection would be at the ends of the conjugate of the same ellipse, supposing its elements were attained by the *rectilinear* divergence of *non-expanding* circles.

SECTION XIV.

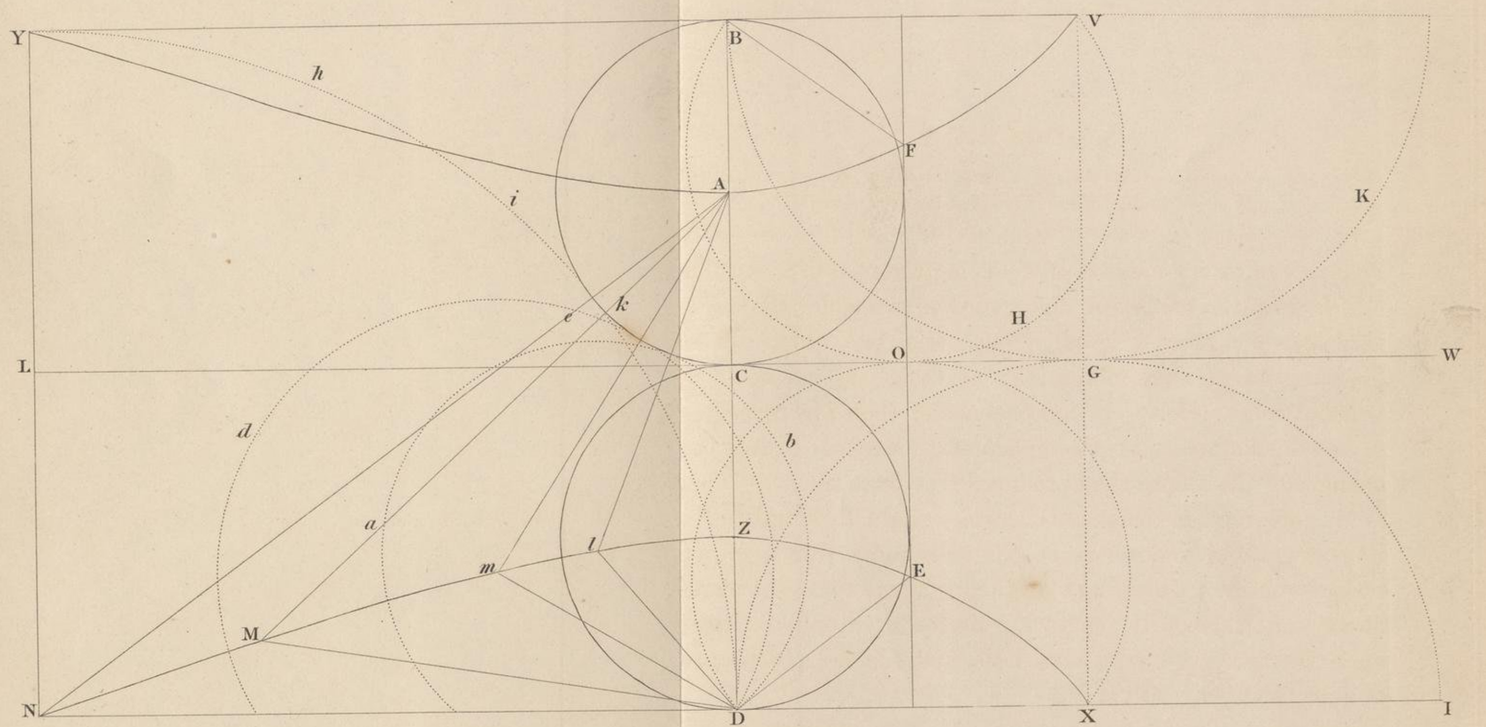
On the self-development of the idea of a variable ellipse, whose outline will be constantly equal to that of the same circular area, *notwithstanding the continuous change of its eccentricity, and of the length of* both *its axes.*

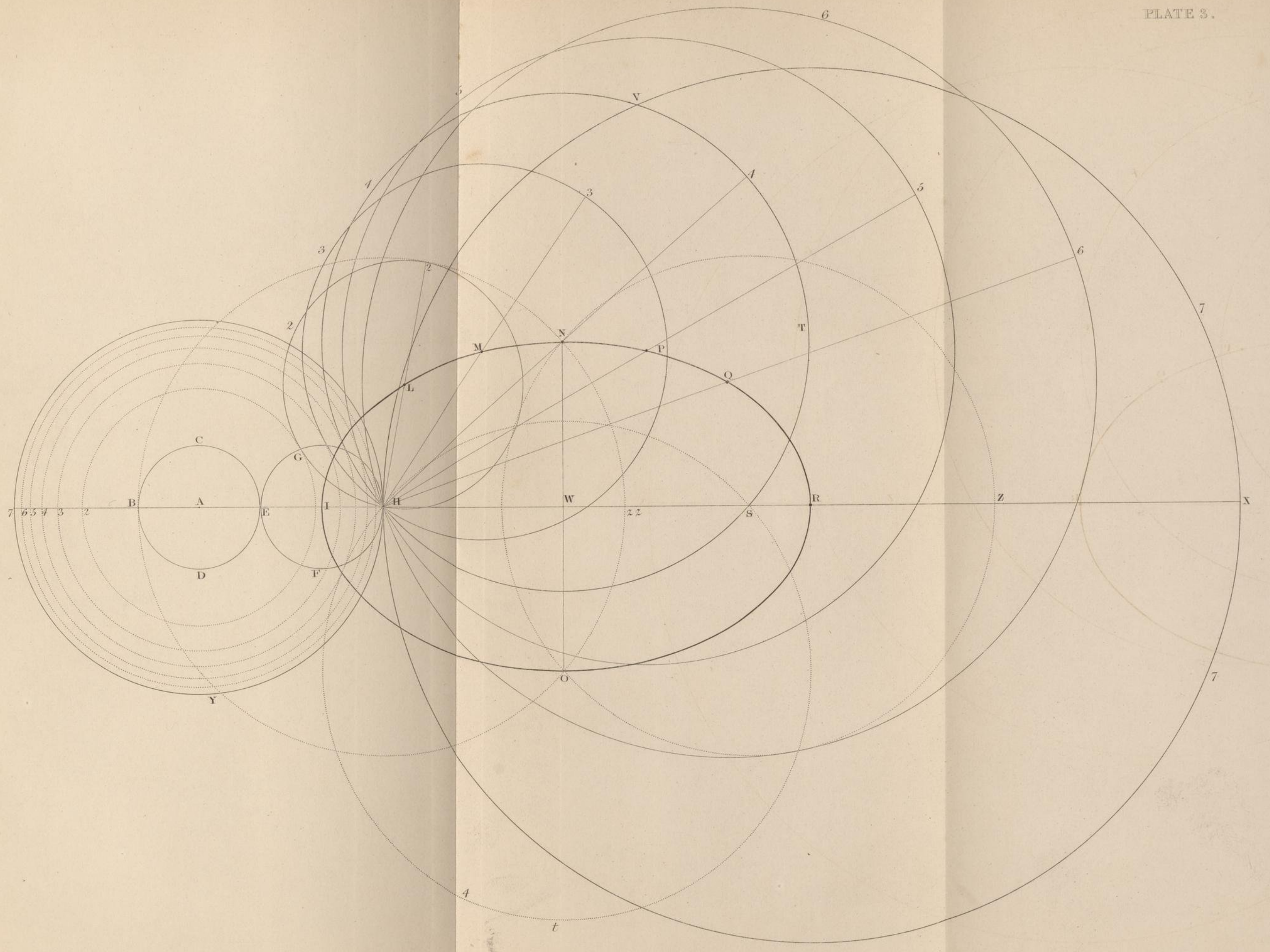
According to our method of deducing the idea of a variable ellipse from the *rectilinear* divergence of two equal *expanding* circles, which were originally concentric, but which are at last in contact circumferentially at their original common point of concentricity, in consequence of that divergence,—we attain the notion of a complicated process as regards the changes of the ellipse thus produced (see page xl).

Its transverse or major axis becomes gradually lengthened: its conjugate or minor axis is gradually reduced to a point; and its outline, which was originally equal to the circumference of either of its generating circles, eventually *collapses* upon the increased transverse axis, and has the appearance of being identical with it.

This alteration of the form of the elliptic outline may take place without changing the quantity of the line itself, provided we can fix upon the exact or relative proportion between the two lengths of the transverse axis,—namely, that which it had when the circular outline first became the outline of an ellipse, and that into which the elliptic outline was absorbed when its foci reached the vertices. It is

PLATE 2.





J. W. Lowry fc.

obvious, that the determination of this proportion will be the same thing as the determination of the rate at which the generating circles should expand during their rectilinear divergence from the central point of their original common area.

According to these conditions, *twice the length* of the transverse axis at the moment of the collapse of the elliptic outline upon it, must be equal to the *original circumference* of the circle which represented the other extreme of the elliptic form, or its incipient condition when it was first changed from a circular to an elliptic area. Hence it follows, that the proportion between the two lengths of the transverse axis, must be to each other as the diameter of either of the original areas of the delineating circles is to its *semi-circumference.* In applying such conditions to our last diagram, each of the delineating circles must therefore have expanded during the process at such a rate that *each of their diameters will be equal to the semi-circumference of the assumed parent area*, (not the expanded area,) when the operation is complete.

The precise relation between the lengths of the diameter and circumference of a circle has never been determined, although that problem has engaged the attention of almost every original mathematician in ancient and modern times. It has been demonstrated that the circumference equals three diameters, and something more than $\frac{14}{100}$ of a diameter. De Lagny has extended the endless fractional difference to 130 places of figures by most laborious calculations, without getting rid of the remainder: the solution of the problem seems to have been given up as hopeless.

As regards the collapse of the outline of an ellipse upon a straight line diametrical to a circle, without any alteration of the quantity of outline employed, it would be of vast importance to be able to ascertain this precise relation between the diameter and circumference of the smaller circle into which the same collapsed ellipse would expand, whilst its transverse axis was gradually decreasing in length until it became equal to, and identical with, the diameter of the *smaller* circle. We are, however, in possession of sufficient data as evidence in support of the doctrine already advanced ; namely, that it is possible to imagine the self-development of a variable ellipse, which will not only go through every change of its eccentricity, but exhibit a continuous alteration of both its axes, while the quantity of its outline will be unchanged, whether it be eventually collapsed upon its own transverse axis and be merged in that diameter, or it be expanded to a circular form and converted into a circle.

The approximation already attained by expert mathematicians of 3,14159, &c. as the relation of the circumference to the diameter of any circle, suggests at once, that if the apparent straight line representing the two sides of the *collapsed* ellipse be considered as half its constant length of outline 1,570795, that line should be to the circumference of the circle into which the ellipse will be expanded or merged, as one-half to a whole.

Let us therefore determine that, by reference to the last section, the diameters of the half expanded circles, which diverge curvilinearly from a common area, should be to that of the *original* area from which they proceed, as 1,570795 to 1, because that diameter is to the circumference of its own circle as 1 to 3,14159, or to the double of 1,570795.

Hence we have the following approximative relations in our problem. The original transverse axis of the ellipse at the moment of its being almost identical with the circle, will be represented by 1,000000. The ultimate length of the transverse axis, when the ellipse has reached the extreme of its eccentricity, will be represented by 1,570795. The outline of the ellipse, whether it be evanescent in that of the corresponding circle, or it be collapsed upon its increased transverse axis, or it be apparent in any stage of the elliptic eccentricity, will be represented by 3,14159, the circumference of the *parent* circular area, whose diameter is 1,000000, not that of the *dominant* circle, whose diameter is represented by 1,570795.

These relations will hold good whether we suppose the ellipse to go through all its changes by expansion from its state of collapse until it is identical with a circle, or by contracting from a *quasi* circular area until it collapses upon its transverse axis.

SECTION XV.

On the harmony between the parabola, the hyperbola, and the corresponding normal *ellipse, which have been deduced from the same original circular area, by our preceding methods of accounting for their self-development.*

Having thus attained the idea of a *normal* rate of expansion in which the guide is the relation between the diameter and circumference of any circle, we may apply it to the method already discovered of deducing the parabolic, hyperbolic, and elliptic *curves* from the paths described by the moving *centres* of expanding circles, which do not diverge from a common area rectilinearly.

As regards the ellipse delineated in that manner, we shall find that if the expanded circular areas, whose centres are at the ends of the elliptic conjugate, have diameters which are as 1,570795 to 1, when compared with the diameter of the parent circle,—the complete ellipse which they will describe will have a tranverse axis equal to the extreme length of that upon which the collape must take place, supposing its variation to be made manifest by the rectilinear method.

It will also be found that when the delineating circles, expanding in this proportion, have reached the limit of their expansion, and their centres converge in the same point which will be the lower vertex of the complete curve, *their common enlarged diameter, added to that of the parent circle, will be together equal to the circumference of the parent circle.*

Exemplification.

This may be shown in Plate 4, where the *dominant* circle FKLH, whose centre is at the end of the conjugate, has a diameter equal to IM the transverse axis of the complete ellipse. Supposing its diameter to be longer than EH, in the proportion of 1,570795 to 1, it will have expanded according to the above normal ratio; and the transverse axis of the perfect ellipse INMO will be of the same length as that upon which an ellipse would have collapsed according to the other method, if its constant length of outline were equal to the circumference of the parent circle EHG.

Then as regards the area HNPO, denoting the utmost extent of the expansion of the delineating circles, whose centres have met at M, the lower vertex of the complete ellipse,—its diameter HP, added to the diameter EH of the parent circle, will equal the circumference EHG.

Now, supposing that a circle having a diameter equal to EH, be drawn *within* the *complete* ellipse demonstrated according to this method; the *circumference* of that circle having its centre at Z, will represent the vanishing form of the *variable* ellipse when it is merged in a circular form. But the *transverse axis* of the perfect *invariable* ellipse INMO, will be equal to half the outline of the *variable* ellipse in its last evanescent stage of eccentricity or collapse, according to the *rectilinear* method of ascertaining its elements. The two lines WV and IM will therefore approximatively represent the transverse axis of the variable ellipse, when it is shortest and longest; *eh* will also give the length of its conjugate, when at the longest; but the conjugate must be gradually reduced to the point Z, when the ellipse is altogether collapsed upon the line IM.

In this diagram therefore, WV represents the *shortest* transverse axis which is supposed to be equal to 1.00000, and is also the counterpart of the diameter of the original circle, supposed to have a circumference equal to 3.14159, the constant quantity of outline in the variable ellipse. We also find the same outline *folded upon* and evanescent in the extended transverse axis IM, which only appears as a single line. Moreover IM is the transverse axis of the perfect and invariable ellipse which corresponds with it, namely, INMO. Furthermore the line EP, is equal to the outline of that ellipse in its first stage of evolution from a circular area, EHG; which is represented by the inner circle W*h* V*e*. This line, EP, has been also shown to consist of EH, added to HP, the diameter of one of the delineating circles expanded from its original area EH*b*, to its fullest extent, with its centre at M, the place of the lower vertex of the definite ellipse INMO.

We have therefore before us a diagram which exemplifies both modes of constructing the ellipse.

According to the first method, two *expanding* circles are supposed to emanate from the central area W*h*V*e*, their centres diverging *rectilinearly* from Z, in opposite directions, until the one is at I and the other is at M, at the moment when their expanded areas are equal to the dotted circles T*g*Z*f*, and Z*k*X*l*; the difference between either of these two areas and their common parent circle W*h*V*e*, will exhibit their expansion, which they must have undergone during the process of converting the outline of the parent circular area through the medium of a variable ellipse, into the apparently single line IM upon which both sides of the ellipse will have collapsed.

According to the other method, the two equal circles BCED and EHG are both supposed to expand, the *directing* circle BCED expanding *in situ* without any separation of its two elementary rings, while the two expanding rings of the other, or parent area, first diverge with their centres guided by the expansion of BCED along the elliptic curves IN and IO, and then converge until they occupy the common area HNPO, and their centres meet at M, the lower vertex of the elliptic area INMO.

The *dominant* area in both methods has the same length of diameter, whether it be measured in HK, in ZT, or in ZX.

There is also an equality between the parent area W*h*V*e* of the *rectilinear* method, and EGH the parent circle employed in the method of delineating the curve with the aid of the *curvilinearly* moving centres.

The two stages of the expansion of the *directing* circle are also shown in the diameters QR and SH. When the expansion brings its circumference to QFR, that line is the guide of the dominant *delineating* area FKLH, and they are in contact at F. When the *directing* circle has expanded to its utmost fixed limit, and is represented by the largest circular area in the diagram, namely, S*g*H*f*, it is in contact with the largest area of the delineating circles in which they are again concentric at M: and the point of contact in that case is the focus of the ellipse at H.

We have thus shown, that there is a perfect harmony in both methods; and that if the dominant areas T*g*Z*f* and Z*k*X*l* were the generating circles in the *rectilineal* method, which did not expand,—the diameter of their original common area would have been equal to IM, and by the time their centres had diverged *without expanding* from Z to H and to L, (the two foci of the ellipse INMO), they would have suggested the elements of that ellipse, of which the outline has been delineated by the *centres* of expanding circles.

Hence, there are really three methods exhibited in this diagram. If the generating circles diverge *rectilinearly without expansion*, the original, or parent, area from whence they emanate, would have a diameter IM equal to the *constant* transverse axis of the ellipse INMO; and although their divergence from that area would have given the elements of every possible eccentricity, before their centres had moved to I and M, there would be no change in the length of the elliptic transverse axis. But by connecting this idea of a *rectilinear* divergence with that of an expansion, (the *dominant* original circle in one case, denoting the extent of the expansion in the other), we must suppose that the original area of the *rectilinear* divergence had its diameter in WV, instead of in IM.

With the object of discovering the most obvious relations between the ellipse, and the parabola and hyperbola which would be derived from the two original circles BCED and EHG, let the curves of the corresponding parabola and hyperbola be described in accordance with the method already explained. Then let the parallel lines *ot*, *mu*, and *nw*, be drawn at right angles to the transverse axis of the ellipse, *ot* passing over the focus, H, *mu* passing over the centre Z, and *nw* passing over the lower focus L. The parabola will cut these lines at *p*, *s*, and *r*.

We already know that *p*H is equal to EH, and consequently to WV, which is the transverse axis of the quasi-circular ellipse in its stage of least eccentricity. We shall find that *r*L is equal to IM, or the transverse axis of the collapsed ellipse, when at its longest. Therefore H*p* will be to L*r*, as the two extreme lengths of the transverse axis of our variable ellipse, are to each other.

But the whole *lower* axis *rw* of the parabola, is twice L*r*, therefore *rw* is equal to twice IM. Hence, as we have already determined that the circular line W*h*V*e* is equal to twice IM, it follows that the lower lateral axis of the parabola, which passes over the focus L, is equal to the constant quantity of outline of the variable ellipse at every stage of change in its eccentricity.

Again, it will be seen that Z *s* is equal to IV, which would be the length of the transverse axis of our variable ellipse when it had attained the *mean* of its extension. Thus it is evident, that there is a perfect harmony between the *transverse axis* of the variable ellipse when it is at its shortest, when it is at its longest, and when it has attained the middle stage of its extension,—and the corresponding intervals between itself and the parabolic curve, when measured from the two foci and the centre of the ellipse, upon lines which are parallel to the elliptic conjugate. We also discover *rw* that the lowest of these intervals doubled, then being an entire diameter of the parabola, is equal to the constant length of line which constitutes the outline of the ellipse during its change from a quasi-circular form to that of an apparently single straight line when it is collapsed upon its extended transverse axis.

As regards the hyperbola in connexion with the constant ellipse, we have already seen that H *o* (being half its latus rectum) is equal to twice EH, or to twice WV. If it be extended until it cuts the prolongation of *n* L,—an operation which requires too much space to be shown conveniently in one diagram,—we shall find that the distance between L the lower focus of the ellipse and the point of section will be equal to the distance between Z, the centre of the ellipse, and S, the farthest point of the *directing* circle, when that circle is expanded, in regard to the ellipse, to its ultimate extent.

Therefore the whole lateral diameter of the hyperbola passing through L, the lower focus of the ellipse, is equal to twice SH added to twice HZ, which twice HZ is the distance between the elliptic foci H and L.

In this coincidence there is a remarkable harmony, because it is evident that this diameter of the hyperbola is larger than two diameters of the fully expanded circle of *direction*, by the distance between the foci of a constant ellipse, which depends upon that expansion for its form.

It is unnecessary to enter more at length upon these harmonies. Enough has been already advanced to prove that when we fix upon the relations between the diameter and circumference of any circle, as the standard of expansion, our whole scheme is one and complete. We attain a *normal* idea of a *variable* ellipse, whose outline, in whatever form it may appear, is a constant quantity; we find that its relations to the parabola and hyperbola, constructed with the aid of the same formal elements and according to the same general principles, are indicative of their all belonging to one system in which even imaginary forms are ideally deduced from each other by processes holding an analogy to those of physical generation.

SECTION XVI.

General considerations on the preceding sections.

In all our preceding remarks it has been attempted to demonstrate, that we are capable of conceiving the idea of a connected series of geometrical forms of a more or less complicated character, in which infinite space, infinitely minute points in space, and *motion*, are the only aboriginal elements of the system. We thus attain the forms of the circle, the sphere, the ellipse, the parabola, and the hyperbola, without breaking the connexion of the self-developing series by any assumptions, or by making use of a figure which had not been previously accounted for.

This scheme may be extended much farther than in the instances already adduced; but it would be needless to advance beyond the self-development of the variable ellipse, whose outline is a constant quantity, notwithstanding all the changes of its eccentricity; such a figure will apply to a physical hypothesis, wherein it is necessary to determine the practical outline of the ultimate chemical atom, supposing its form to be variable.

Independently of this result of our mode of applying the *ideal* progressive development to *chemical* geometry, the method has the advantage of compelling the reason to accustom itself to commence inquiry in *all* matters in which the generation of new ideas is concerned, by extending its researches to *first* conceivable principles or *elements*. The discipline prepares the mind for an impartial consideration of the problem involved in the *prevalence of certain numbers in nature*. It also lays the foundation for an unprejudiced review of the doctrines of many eminent naturalists, who maintain that the *whole system of nature is one of gradual development*; and that species hold the same relation to genera, and genera to orders, or to higher categories, as that of varieties to species. *Every botanical or zoological variety is undeniably a self-development of new attributes of form, and of other instinctive properties.*

The basis principle suggested by this incontrovertible method of dealing with the generation of geometrical figures is, that, even in reference to our ideas of immaterial forms, every image can be accounted for as the offspring of some more simple form, produced by applying the element of *motion* in accordance with the most obvious method of its application. The ellipse for instance is the curve in which the heavenly bodies *practically* hold their relations of motion to each other; and this curve is the necessary consequence of motion applied *theoretically* to circles, and to their centres under self-evident and self-developing conditions. In another essay it will be shown that this curve is equally applicable to the form of the presumed ultimate constituents of all distinct bodies, even supposing such atoms to have been generated and absorbed, and to be constantly liable to change during their individual existence. Having once determined the rule of the change, or the elements of a form, which may be successively that of an oblong spheroid, a sphere, or an oblate spheroid, we have attained a geometrical condition, which seems to have the same inevitable power in nature as that which is connected with the connexion between cause and effect in more obvious and indisputable physical phenomena. Nothing in Nature, however accidental or capricious it may appear at first sight, can be the result of chance. There is a reason for everthing; in other words, there are abstract laws, in obedience to which the most seemingly unaccountable phenomena are made manifest; and this *necessity*, when traced to the highest comprehensible causes which are within the domain of our intelligence, will be at last found to be merged in the same category of abstract truths as those of logic and mathematics.

ESSAY II.

OUTLINES OF A PHYSICAL THEORY.

SECTION I.—Introductory.

On the primary development of motion *in relation to individual portions of the physical world.*

Motion and rest are decided opposites, as regards "*modes* of being" in physics; but our idea of activity *in the abstract* is a co-ordinate of *abstract being*, and it can have no opposite. In this respect, it holds an analogy to an arithmetical, geometrical, or logical truth.

The most refined ideal type of motion in metaphysics is to be found in our idea of the *passing moment*, or of an *abstract progression in* time; and in our conception of this type, we do not need any such *spacial* condition as *locomotion*, although we can entertain no notion of a change in the physical world, unless we imagine that some point-like localised centre of a force, or some individualised portion of material substance, or some transferable influence, like that of electrical and magnetic induction, has *moved* from one spacial locality to another.

Even in our mathematical method of applying the principle of this sort of motion to *existing* forms, as the ideal force which causes the generation of *new* forms, the existence of space as an imaginary medium of the operation is indispensable.

Motion in the abstract, however, is the synonym of activity; and the idea of CONTINUOUS BEING is our most refined idea of abstract activity: we may therefore affirm, that "to continue to be" is a species of activity, which does not depend upon cause and effect; and all abstract truths may, critically speaking, be thus far said to be active entities, *because they* *continue to be;* but in the general and conventional meaning of the word "activity," it implies the influence of some motive cause.

It is therefore in relation to "cause and effect," that we may consider the motion and rest, or activity and quiescence of any object of our conception, as opposite and contrary *modes* of being.

Absolute being itself is the opposite of *non-existence*, and this can only be applied to the first conceivable principles of metaphysical reasoning, in which *being* is the synonym of abstract *truth*, while *non-being* is another term for absolute falsehood. Hence we arrive at the evident inference in dialectical reasoning, that TRUTH, continuous being, and activity in the abstract, are the *co-ordinate opposites* of FALSEHOOD, *non-existence*, and absolute *quiescence*. It also follows as a logical consequence from this method of considering activity in its most elementary character, in relation to *time*, that it is one of the everlasting attributes of the Supreme Being, or of the All in All, the Universe itself.

The philosophers of the Eleatic school, who entered the most profoundly into the great problem of "Being" in the abstract, as opposed to "Non-being," appeared to have erred *in limine* upon this question, because they insisted upon the absence of activity or motion in regard to absolute existence. By adopting this course, they immediately arrived at the paradoxical belief, that every phenomenon connected with motion or change in the universe was a deception of the senses. That such was the doctrine of Parmenides is to be inferred from his famous treatise, of which fragments only have been handed down to us. It was only one step from this fallacy to the monstrous tenet of the Sophists, that "nothing exists or can exist."[a]

[a] The discussion of this question may be found in several dispersed passages of Plato's Dialogues; more especially in his *Sophist* and *Parmenides*. Parmenides of Elea and Gorgias held the same relation to each other in the

The fundamental error of Parmenides, was his denial of any absolute activity in "being" as a universal and a whole; and in his confounding the manifestation of activity *in phenomena,* as regards space as well as time, with activity *in the abstract*, or with respect to time alone.

But when we meditate upon the two first opposites in our comprehension—being and non-being—without reference to our ideas of "cause and effect," we cannot avoid the conclusion, that *quiescence in the abstract* can only be the co-ordinate of non-being or *non-entity*, even as regards eternal time; and that it must therefore be the supreme falsehood. In his admirable dialectical method of attacking the Sophists, Plato even advances beyond this mode of argument, when he maintains, that the existence of their *idea* of *non-being*, is in itself an *entity* or *something* which must be *a being*, because it is in existence; and that to that extent only, were they plausible in assuming that activity may be treated as a mere creature of human imagination.

However, without refining, as he did in his dialectical system of controversy, we may content ourselves with asserting that *absolute* quiescence can only be the co-ordinate of *non-being*, or nihilism, *in the abstract*. *Relative* quiescence, in regard to "cause and effect," is conceivable, when we connect the idea with our notions of physical or of mental *repose*, admitting the existence of matter or of mind, which need not be always in activity: but under such conditions it is evident that we do not deal with *activity* in the abstract; we only affirm that there is no action of "cause and effect" in such a possibility.

If we could imagine the whole spacial universe to be devoid of physical phenomena, or the great mind of nature to be completely inert, or if we were disposed to admit the atheistical

progressive development of the *nihilism* of their days, as that of Berkeley to Hume in the last century, when the same cycle of error was repeated without reference to the Greeks.

hypothesis, that there is no other sort of mind than that which acts automatically in the material world, we might nevertheless defy the sophist to prove that "abstract being" can be otherwise comprehensible than in an inevitable connexion with activity *in the abstract.* In our elementary considerations upon the origin of generated forms, be they those of ideal geometrical generation, or of individualised portions of that material substance which, so far as we can comprehend the problem, must pervade infinite space,—it is important to bear in mind, that the type of activity is to be found in the inevitable progression of the *passing moment* in time; and that our most refined idea of motion is therefore independent of space, distance in space, or the material substance which occupies it.

While we are thus prepared for the admission of the doctrine, that *activity* and *being*, in regard to abstract ideas, are coordinates,—we find that in the self-developing mathematical progression of new forms, already described in the preceding essay, *locomotion*, as opposed to spacial *inactivity*, is the inevitable procreative principle of higher and more complicated forms. Let us now proceed to the application of this principle to elementary physical considerations.

Sir Isaac Newton supposed that "God in the beginning formed matter in solid, massy, hard, impenetrable, moveable particles;" and most modern chemists have either wholly, or conditionally, adhered to this doctrine, by assuming that the ultimate atoms or last imaginable molecules of bodies, are aboriginal physical entities which were either created such as they are at present, or have existed from all eternity in their present condition.

The opposite hypothesis has been hitherto refined upon to its nearly ultimate terms by Boscovitz, who denied the existence of any *atomic* molecules or *corpuscular* constituents of substance. He imagined that point-like forces or energetic germs, which did not occupy any region of space, were the ultimate elementary principles of material phenomena; and that all such phenomena depended upon the action and reaction of these points upon each other. Various modifications of this hypothesis have been suggested by chemists and natural philosophers since the death of Boscovich.

In the Newtonian theory, the force of attraction is evidently the result of mutual reciprocity; but Newton did not attribute the phenomena of astronomical *repulsion* (which is the opposite of attraction), to the same general principle. In explaining the orbitual movements of the planetary bodies in space, he was obliged to assume the existence of a motive or *projectile force*, the origin of which he did not account for, —and to imagine a law or condition, to which he applied the term of *vis inertiæ*. This negative condition (inappropriately called a force) was merely the assumption, that a body would remain at rest for ever unless it were moved, and that, when once moved, its motion would continue for ever, unless it were impeded by some mechanical obstacle. It was also an assumption, that the direction of the movement must be rectilinear; but he accounted for the deviation of such a body from its rectilinear direction, by insisting upon the counter influence of a *centripetal* force. He thus explained the orbitual movements of the heavenly bodies as the consequence of a contest between the mutually gravitating influence of *centripetal* attraction and the *rectilinear* impulse of *projection*, which he called the *centrifugal* force.

The origin of *motion* in his system, so far as the centrifugal tendency is concerned, was treated as a sort of mysterious and insoluble question beyond the discovery of human intelligence, in the same way as that of the ultimate molecule of each compound of atoms was in the same theory.

Still, the fundamental principle of the Newtonian scheme of physics was *mutual attraction*; and this idea of a *relative* force, which is generated by reciprocity, must be entirely separated from his mechanical notion of a *contest* between *centripetal* and *centrifugal* forces. Such an hypothesis resulted from his endeavour to reconcile his admirable discoveries with those astronomical phenomena in which there is the manifestation of mutually repulsive tendencies. In his days, the laws of chemical affinities were not understood, and those of inductive electricity were little thought of; and it is wonderful, that when the elementary principles of chemistry and electrical forces were scarcely conceived by natural philosophers, our great mathematician should have been enabled to deduce so sure a foundation from his mechanical and astronomical observations in regard to gravitation, as that which he bequeathed to future astronomers and electricians.

The first idea of accurately measuring all chemical and electrical forces is to be found in his laws of gravitation. It is true that he only applied it to the *attractive* energy, and not to repulsion, and that he was obliged to account for the phenomena of repulsion by the supposition of the centrifugal force; but the same general mathematical laws, and the same principle of reciprocity, are alike applicable to motion produced by centripetal attraction, and to that which results from its opposite, namely, inductive repulsion. Whether bodies approach or retire from each other, their movements are in accordance with the same system of dynamical laws, while one general motive principle, that of an *electrical force generated* by their *reciprocity*, may mutually attract or repel them according to their respective electrical conditions.

Boscovich appears to have entertained a complete conviction of the existence of some *general* cause of motion, although, from his want of electrical knowledge, his scheme was imperfect. He also advanced farther in the physical analysis of matter itself than those who had preceded him; but by doubting the reality of an aboriginal *material substance* which holds an analogy to Newton's ultimate atoms, and by merging the whole physical universe in *immaterial* forces which did not themselves occupy space exclusively, he virtually advocated the doctrine of Berkeley and other pure idealists.

Now, when we suppose that the *substantiale* of matter, independently of its energy, is a reality,—that it is the all-pervading co-ordinate of infinite space,—that in its homogeneous and completely inactive condition, it is endued with every *potential aptitude* to develope the phenomena of nature,—and that in this *normal state*, it is infinitely divisible but undivided, compressible but uncompressed, without form in its inactivity and entirety, but as regards each segregated portion of the universal mass, necessarily having a defined outline if it constitutes the substance of an individual body or of an ultimate molecule,—we discover logically, that its *absolute existence* must be considered an elementary postulate in physics, and that it should be treated as the *passive* material of the great system of nature, although we can only describe it in terms of such a negative character, as are used by the Indian philosophers in speaking of their *Maia*, or illusive and imperceptible basis of the whole material world. Indeed there is no other object of our meditation but space itself, which holds an analogy to this substantial compendium of physical *aptitudes*.

Without some such basis, it is impossible to comprehend the mode in which the pointlike centres of forces imagined by Boscovich could promote the phenomena of a corporeal system. With it, his doctrine is perfectly comprehensible; for we can understand that the germs of his forces, which must have their specific localities in space, hold the same relation to mathematical spacial points, as the all-pervading substance does to infinite space itself. The infinitely minute germs of the forces may be the *physical* counterparts of infinitely minute individual points in elementary mathematics, which exist in space without conveying the idea of their exclusively occupying any region of space: yet they so far differ from abstract mathematical points, that they not only represent the localities, but they are all supposed to be endued with an automatic energy, in relation to each other, and to embody the motive principle which we imagine, and apply *ideally* to points in the mathematical method of accounting for the generation of our new geometrical images.

Boscovich's idea of immaterial centres of forces is necessarily a compound one, including the notion of each forcible entity *itself*, as well as that of its *place*. It is therefore in harmony with such an opinion about a *double* characteristic of his centres of forces, (the mathematical point being the counterpart, both of an energetic entity and of its specific spacial locality), that infinite space should be represented in the physical world by the two-fold reality of an all-pervading *passive substantiale*, which is its counterpart, and by the infinitely extended spacial locality, in which all the locomotive and other phenomena of nature must take place.

Neither of the two opposite physical elements,—the material *substantiale*, and the germs of forces,—could be separately capable of promoting the development of the formal and other phenomena which come under the observation of the naturalist, unless they were practically in relation to each other.

There may be immense regions of space in which the homogeneous substance is quiescent, because it is not vivified by the *energetic* entities; and these central forces themselves may be derived in some inexplicable metaphysical mode from the great Mind of the Universe, according to laws which, owing to the bounded character of the human intellect, we cannot understand: they may be made manifest at stated intervals in time, in any particular region of space; and after having exerted their destined influence upon the previously quiescent homogeneous substance pervading that region, they may cease to act upon it. The same sort of difficulty as that which the psychologist encounters, when he extends his inquiry to a *first cause* of spiritual individuality, is met with in this hypothesis.

But the precise commencement of the physical process, which *individualises* any distinct atomic portion of matter, in relation to the universal mass and to actual phenomena, may be supposed to occur when any two such pointlike centres of forces, as those imagined by Boscovich, reciprocate with each other through the medium of this otherwise quiescent substance, and agitate the intervening line of matter. In this case we may account for the generation of an *actual inductive force* holding an analogy to many other developments of physical energy, which are only perceived in their effects upon matter. Gravitation itself seems to be the result of a force of this description, and all the *inductive* phenomena of electricity, more especially when secondary and contingent magnetic currents are produced by galvanic currents, can only be accounted for under the supposition that one sort of force may generate another, without ceasing to exert its own original influence.

The whole system of Nature appears to be one of gradual and successive development, not only as regards the forms of bodies which are generated in an improving series, but even with reference to the many sorts of electricity which are made manifest by a series of generative processes, each new sort being more powerful than that which was its parent: a transcendental physical force is at last generated, which almost resembles the *mental power* itself. According to the analogy, therefore, the first development of any activity in the material world, although it be the *potential* germ of every other physical energy, need not be accompanied by any phenomena in dynamics, like those of locomotion or of attraction.

Hence we find, that admitting the theory of Boscovich and his doctrine about pointlike *centres* of forces, we reduce them essentially to pointlike immaterial entities, whose only *immediate and direct* influence may be the promotion of an inductively occasioned agitation in the matter *which lies between such points.* The force which is thus developed, is most probably the *primal* physical activity, and the parent of all the others which are derived from each other in an improving series: but in thus reducing the elementary principle of all physical forces whatever, to the *result* of a reciprocity between pointlike entities, it is obvious that we attain the idea of something so peculiar, with regard to the characteristics of these localised beings, that the term " force," cannot be strictly applied to *them.* This consideration at once involves us in one of the most recondite questions of metaphysics, since the pointlike essences in question, although specifically localised in space, only suggest the idea of " formless" beings without active or acting energy, unless they be in connexion with each other, through the medium of the matter which is agitated in consequence of their reciprocity. The same remark, indeed, applies to every sort of inductive force in nature, if we do not admit the existence of the so-called *vis inertiæ.*

Finally, we should remember, that the whole Newtonian theory of gravitation, and the consequent locomotion of the planets in space, is based upon the principle of mutual attraction, or, in other words, upon a reciprocity between bodies, which correspond with the pointlike centres of forces in the theory of Boscovich: the phenomena of chemical processes may be traced up to the same general system of inductive relations; while the substitution of an electrical or magnetic force of mutual *repulsion* under certain conditions, for that of *attraction*, (both these causes of locomotion being different modes in which the same general result of reciprocity is made manifest), will harmonize with the notion, that every sort of physical activity derives its origin from the *quasi-ideal sympathy or antipathy* between bodies composed of atoms, or between individual atoms themselves, or even between the pointlike centres which, according to the mathematical hypothesis submitted to the reader in the present essay, are the *constant poles* of each individual atom.

The aboriginal development of material individuality, or the generation of the ultimate atomic constituents of a body, may therefore be considered as the primary process of the great automatic system which the materialist calls Nature. Every physical individual may be amenable to the conditions of birth and death, or of a beginning and an end, as regards its special existence: even the pointlike centres imagined by Boscovich may be generated in accordance with some laws of transition between physics and metaphysics, and cease to exist when they have fulfilled their appointed physical destinies. The same region of space, where they have exerted their energies over the homogeneous substance which occupies it, may be again the theatre of the activity of new and similar germs of force; the same material substance may be the *substantiale* of new ultimate atoms, generated by a similar process. But this hypothesis does not suggest the notion of an absolute creation of matter in its quiescent character, nor does it lead to an inference that the great system of nature must have had *an absolute* or universal beginning. It will, however, be shown in a future page, that this apparently atheistical conclusion can be reconciled with our purest conceptions of a Supreme Being, and of an overruling Providence.

We should never forget that although *matter* and the *forces* which act upon it, and give it all its forms and perceptible qualities when its aptitudes are made manifest, may be the ultimate conceivable elements of the physical world,—the power of the human intellect is able to comprehend many other elementary principles of a metaphysical character which are altogether independent of material phenomena; the self-evident laws of arithmetic and geometry, the truths of logic, and all other transcendental objects of philosophical disquisition which present themselves to a speculative mind, neither depend upon the existence of matter, nor upon the energy which inspires it with a sort of vitality.

We cannot understand the possibility of *abstract truths beginning to exist*; and there is no greater difficulty in supposing that matter itself in its homogeneous character as the co-ordinate of infinite space, or that the *general* system of nature, should have *eternal* attributes, than that abstract truths themselves should be independent of our ideas of a beginning and an end.

SECTION II.

On the practical application of the variable ellipse to the assumed changes of form in the outline of the ultimate atom.

THROUGHOUT our previous remarks it has been maintained, that the abstract principle of *contrariety* is a sort of *power* in relation to the generation of new ideas of form. Motion applied to the straight line rotating upon its medial point,—or to two points which are always at the same distance from each other, while they are actuated by a tendency to move in *opposite* directions,—developes the idea of a circular *circumference*. When the motive principle is supposed to be transferred to that circumference, and the original diameter is in the *opposite* condition of not changing its position in space, this double notion of a newly imagined *contrariety* suggests the idea of a sphere.

The tendency of such individual substances, as distinct portions of matter, to attract and to repel each other, may be considered physical manifestations of the prevalence of *contraries;* and if we persevere in applying our abstract geometrical notions to the development of a physical system, by supposing a succession of antagonistic tendencies to have been gradually made manifest in the processes of nature, and more especially in her elementary phenomena, we shall be able to account for that first process upon which all her more complicated operations must depend.

It has been already suggested, that matter in its aboriginal and perfectly *quiescent* condition is the physical counterpart of Infinite Space itself, and that this universal substance (which may be called ETHER) is the *material* out of which all bodies are composed,—that in this primal condition, matter is non-atomic and without form, when considered as a whole, but capable of division into distinctly separate portions as Space is,—that all forms which it may assume, and all qualities with which it may be endued, are but the temporary attributes of certain portions of this universal substance, and that every such formal or other manifestation of a quality, has its beginning and end, and is liable to change in the mode of its development during the limited period of some special state of being,—that the *energy* which promotes such changes, including the first separation of any one portion of the all-pervading material substance from the universal mass, is the counterpart of the *motive* influence, which according to the mode of its application, promotes our successive ideas of formal changes in the generation of new geometrical forms,—that the ideal mathematical points, in relation to our abstract or immaterial notions of form, are realised in the physical world, by *pointlike localities* in the quiescent material substance, in which the *germs* of the primal physical forces of Nature are in existence as individual entities.

It has also been assumed, that the first physical manifestation of *motion* is an action of *sympathy* or *reciprocity* between any two such pointlike germs of force, which acts upon the line of substance existing between them, in a manner analogous to the influence which causes light, according to the doctrines of the vibratory optical theory. We can imagine the existence of a magnetic or electrical influence of this description, which in itself is neither of an attracting nor of a repelling character, but which is nevertheless sufficient to give a distinctive *speciality* to the line of substance intervening between the two reciprocating germs in question.

Now, in these analogical assumptions, founded upon our preceding mathematical method when applied to matter, we do no more than realise our elementary abstract ideas of space, of points in space, of a limited distance between any two points, and of a *motive influence depending upon their reciprocity*. Our first physical phenomenon in this case, is only a change in the condition of the *substantial* straight line between two points, or of the intervening matter, which is not yet supposed to change its position in space, but to be endued with a sort of *non quiescent* quality distinguishing it from the quiescent matter around it.

The next imagined operation of Nature, in reference to the formation of the ultimate atom, is suggested by one of the simplest experiments in electricity. A skein of thread suspended from the conductor of an ordinary electrical machine, will undergo a change when the machine is put in motion, which converts every line in the skein into a repulsive individual, as regards every other of its lines; and if the threads be all connected or tied together *at each end of the skein*, while they are free elsewhere, the whole skein will gradually assume the appearance of a spheroid in consequence of the mutual repulsion of the free portions of the threads: the two ends of the skein will gradually approximate as its component parts become more and more charged with an excess of the same sort of electricity.

Pursuing the analogy,—since space itself is infinitely divisible, we find no difficulty in supposing that the line of material substance between the two *aboriginal* pointlike germs should be capable of division into a vast number of distinct subordinate lines, when it is thus acted upon by the primal sympathy between these germs; and that each of the lines of the intermediate substance should repel each other, as threads do in the ordinary electrical experiment.

But it is one of the conditions of the problem, that the material substance (or ETHER), IN ITS PRIMARY STATE, *is incapable of extension or expansion, although it may be compressible*, because we must suppose that it is then at the extreme or incipient limit of any change in its character, and that, like a free vapour (which, when unrestrained by compression, is incapable of farther dilatation,) the aboriginal ether is at its climax of expansion, when it is perfectly quiescent. This condition obliges us to assume, that the mutually repulsive constituents of the compound line of ether cannot be longer than they were before they began to be curvilinear; yet they might act *mechanically* upon the pointlike *terminal* seats of the reciprocating forces, from whence their own energy was originally derived. Like the two ends of the artificial skein, the primal germs of the compound line of ether would approximate, if its individual lines were incapable of being lengthened as they became *convex*; and we thus attain the idea of a skeleton spheroid, whose poles are gradually approaching each other, not in consequence of their own attraction, but because they are mechanically drawn nearer to each other by the mutual repulsive tendencies of the lines which connect them.

We may imagine this process to continue until the poles, which were originally at the end of a compound straight line, become those of a complete sphere, or a spherical skeleton, and even until they are eventually brought into contact by the mutual repulsion of their connecting lines. The original sympathetic relation would terminate, and *the whole form would disappear*, as soon as that relation was at an end; because the hypothesis supposes that the original *speciality* of the substance of the atom, (as regards the universal etherial mass from which it was first distinguished), must depend upon the mutual reciprocity between two distinct germs; and that this *duality* must cease to exist when they are blended in the same spacial point. Under such a condition they would no longer act upon each other through the lines which constitute the surface of the atom; and the lines themselves would lose that distinctive electrical attribute, which, in the first mode of its manifestation, occasioned their mutual repulsion.

According to this method of accounting for the generation of the atom, for its changes of form, and for its ultimate evanescence, we may conclude that the difference between matter in its etherial or *non-atomic,* and its individualized or *atomic*, conditions, depends upon a change in its state of being, produced by a distinct portion of the etherial mass which pervades Space, undergoing the influence of an *incorporeal* force. It is evident, that to call such a force *a fluid*, would be inconsistent with the hypothesis: the only object of our comprehension to which we can assimilate it, is the influence of electrical induction. Such being the elementary physical hypothesis, let us proceed to the application of our purely mathematical ideas to the *form* of the atom.

It has been already maintained, that homogeneous matter in its etherial state of being, is incapable of *dilatation;* and admitting the indestructibility of its manifold *potential aptitudes*,—the quiescent state of the substance implies an utter absence of physical activity, when it is in its first or *zero* condition. A newly developed tendency to expand may be supposed to exist, where there has been a *previous compression;* and the compression of non-atomic matter may be accounted for as a consequence of the formation of the atom; but unless there be some interference with the *normal* condition of the etherial substance, which would otherwise hold the relation of a *plenitude* to infinite space, we cannot understand the possibility of its being subsequently compressed.

According to our hypothesis also, the general boundary of the lines which compose the atom must occupy a greater portion of space, when they have arranged themselves in a spheroid or in a sphere, than when they are in the general form of one bundle or skein of *straight* lines between two points.

We are at liberty to assume, that the surrounding ether may pass through the surface of the atom composed of lines with interstices between them, and may fill up the internal hollow of the *shell;* for it is evident, that our hypothesis necessitates the existence of a region of space *within the mutually repelling lines*, which region cannot be occupied by those lines themselves, if they arrange themselves in a regular curvilinear form in consequence of their mutual repulsion. But we cannot maintain this supposition, unless we imagine, that the interior of each atom is an *absolute void;* because were it otherwise, the reciprocity between its poles would be maintained *diametrically* instead of *superficially*, which idea militates against the notion that there should be any repulsive energy in the lines, and consequently against the whole hypothesis accounting for the formation of the atom. Hence we discover, *that the existence of a void within the lines of the atom's surface*, which is not even occupied by the aboriginal ether, is a necessary part of the whole argument; and the *imperviousness of the shell* may be explained by attributing a repulsive energy to the lines constituting its texture, not only with regard to each other, but to the neighbouring ether which surrounds the atom.

We thus find a cause for the compression of the ether in proportion to its being unable to occupy a portion of space, and for the development of some law, which regulates the extent of the compression in relation to any given distance from the surface of the atom, whose internal *void* had disturbed the general equilibrium.

Such a consequence of an interference with the aboriginal condition of the etherial medium surrounding any individualised void portion of space, may account for other physical phenomena, more especially for that which is made manifest to our *senses* in the so-called imponderable *substance* of heat: but considerations upon that point would lead us into details which are of a less decided mathematical character than those more immediately connected with the form of the atom. The object of the present section is to reconcile the notion of a continuous change in its form with the obvious doctrine, that the interpolar lines of its texture must always be of the same length, notwithstanding its constant variation of shape, and the constant approximation of its poles.

If the superficial shell of the oblong spheroid, of the sphere, and of the oblate spheroid, (through all which forms the atom is supposed to pass during its existence), be composed of lines of the aboriginal matter which is inexpansible, we cannot account for any *formal* change of shape in those lines, without assuming that they individually assume the shape of some curve, and that as the atom's *equatorial* diameter becomes longer, its *polar* diameter or axis must become shorter.

That the ellipse is the curve in which the heavenly bodies move in space, is a fact too well known to need comment. We shall find that our atomical hypothesis will also coincide with the elliptic conditions, when we assume that the *variable* ellipse already accounted for in the preceding essay, is the ideal model of the form in which the variable atom goes through its changes.

Reverting to the diagram (plate 4), let the points I and M represent the two poles of the atom, or the localities of the germs of force influencing the line or bundle of lines of the original homogeneous matter represented by I M, and enduing it with a sort of *activity*, which individualizes or specializes it in relation to the surrounding *quiescent* matter.

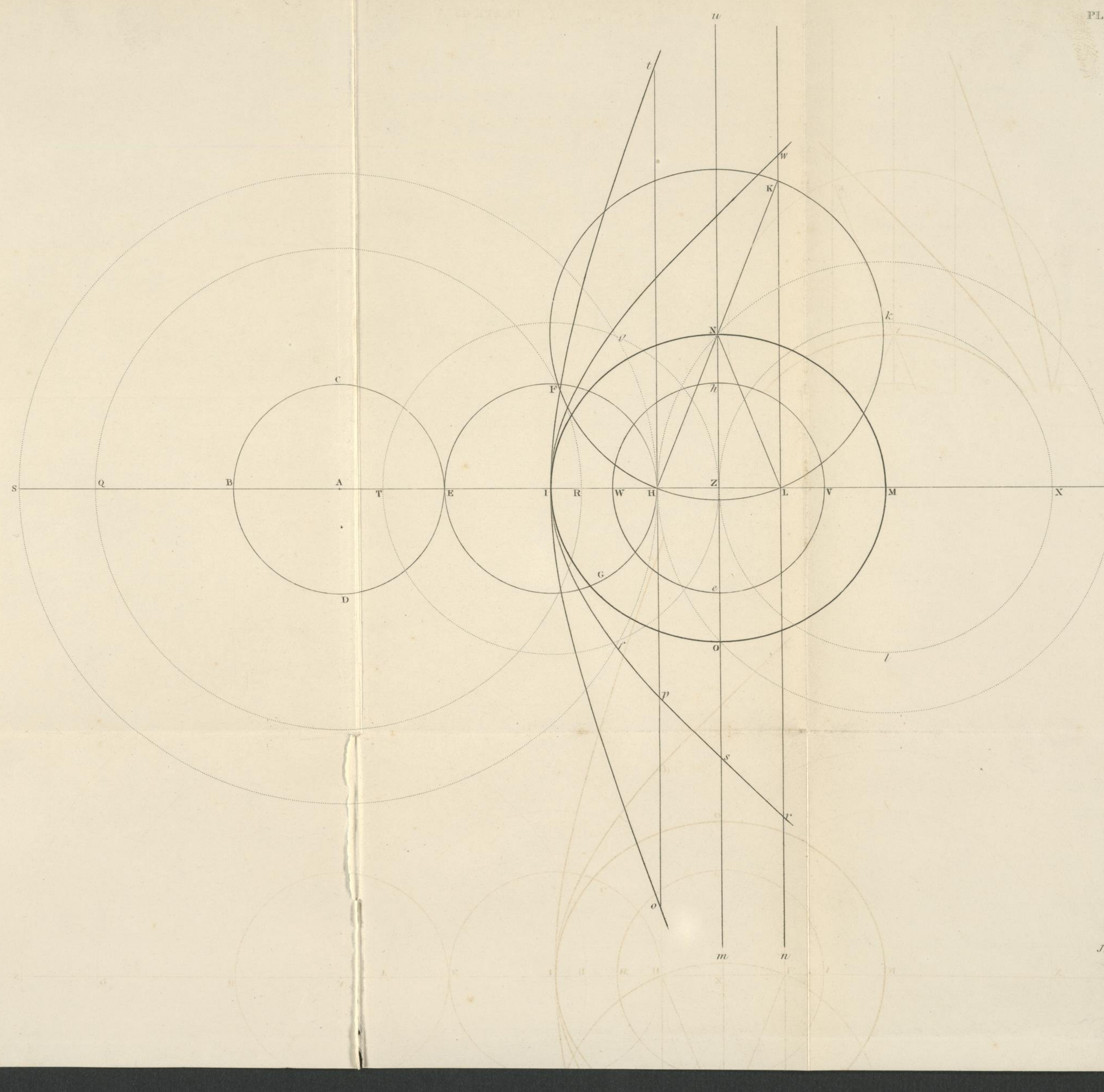
Then let us suppose that in consequence of the lines being thus endued with a special quality, they repel each other, and that each gradually assumes the form of one-half of a variable ellipse, the eccentricity of which is constantly decreasing, until any pair of such opposite lines would be represented by the circle W*h*V*e*. Its poles in the mean time would have been moved from I and M to W and V, in consequence of the straight lines between I and M having gradually attained the semicircular form of W*h*V, and W*e*V. It has been already assumed on physical grounds that this approximation of I and M, or of the poles of an atom, cannot occur in consequence of a mutual attraction, but of the *mechanical* process of their being, as it were, drawn together by the increasing curvilinear tendency of the lines by which they are connected.

Having arrived at this stage of the process, and attained the idea of the *same quantity of outline* being converted from a bundle of straight lines into the skeleton of a sphere,—we have now to institute a parallel between the farther change of the atom from a sphere, to a spheroid so *oblate*, that it vanishes in the form of a *flat disc*. In order to accommodate this physical process to the mathematical model, we must suppose, that as soon as the sphere begins to be oblate, the poles of the atom are represented in the diagram by the ends of the conjugate *eh*, and not by those of the transverse axis W V. In reality, the poles of the atom itself are not changed in the continuous *physical* process, for they will continue to approximate until they meet at Z; but when compared with the single diagram, they must be assumed to be transferred to *e* and *h* as soon as they have reached W and V.

Then, by the reversed mathematical operation which re-extends the elliptical transverse axis from its contracted length WV to IM, we shall find that *that line* may be made to represent the *equatorial* diameter instead of the *polar* diameter of the atom,—while the conjugate *eh* gradually diminishing, will represent the farther approximation of the atomic poles, which will have converged to the point Z. Thus the *equatorial* section of the *oblate* spheroid will be represented in its last stage of oblateness by IM, which is the transverse axis of the mathematical ellipse in its last stage of eccentricity, while the convergence of the germs of force at Z, will have terminated the existence of the *speciality* which they imparted to the substance constituting the shell of the atom, during the whole process; and that substance will be blended with the aboriginal ether in its immediate neighbourhood.

This method of accounting for the possible generation of the ultimate atom, for a constant tendency to change its form during its existence as a special individual, and for its eventually ceasing to exist,—is submitted to the reader as the *basis* of a physical and chemical theory, in many respects resembling that which was originally suggested by William Higgins, but which is generally attributed to Dalton, who introduced it in detail to the notice of the scientific world. Their point of departure was the admitted existence of *ultimate* atoms; but they did not inquire, whether these last indivisible constituents of chemical bodies were generated from some common material, or whether they were elementary entities, whose origin, if they ever began to exist, was beyond the reach of the chemical philosopher. Modern discoveries in electricity have, however, established, that there is a sort of sympathy between bodies, which does not necessarily produce spacial attraction or repulsion, but is never-

PLATE 4.



J. W. Lowry fc.

theless perceptible in the effects occasioned by their spacial relations to each other being changed. All the phenomena of electrical *induction* seem to belong to this class of influences; and they almost approach our notions of metaphysical processes.

The great physical system which we call Nature, may be as eternal in Time, as the theatre of its operation may be infinite in Space. Every logical and metaphysical argument is against the notion, that there could ever have been a beginning, or that there can ever be an end to its activity, *as a whole.* But every individualised portion of the *atomic* world may have had its beginning as regards its own speciality. New atoms may be starting into individual existence in Space at every moment: in one region they may be nascent, in another they may be evanescent, after having existed, individually, during countless millions of centuries, and after having been the ultimate constituents of every sort of chemical simple or compound body, when their change of form was suitable to their incorporation in the particles which compose such a body.[b] The idea of an *absolute* beginning or end of the physical world, is contrary to all philosophical deduction: but that of a *relative* beginning and end of every existing form of matter, is supported by inference, and reconcilable with our abstract notions of an Omnipotent Providence.

[b] It is necessary to remark, that in the application of this doctrine to phenomena, the author supposes the changes in the form of the atom to occur by sudden starts or at intervals, which are determined by specific chemical laws. There is no other method of accounting for many other analogous phenomena, such as those of the relative distances of the planets from the sun and from each other, than by assuming that the *gradual tendency to change is interfered with* by distinct laws of proportion in the abstract, both with regard to time and space. This supposition enhances the presumed superior power of *numbers.*

SECTION III.

On the prevalence of contraries *in relation to the* primal motive ENERGY of Nature.

IN the *mathematical* mode of accounting for the self-developing generation of our ideas of form, we have supposed that the two movable but inert elementary points are the exact counterparts of each other. But when we apply this doctrine to *physics,* we are obliged to commence by conceiving as a postulate, that each of these points has attached to it an inherent energy, which is the practical representative of the *ideal* moving force applied to the inert point of the mathematician. One of the first problems in physics is therefore the question, *why* any such automatic energy should exist in Nature, or *why* there should be any active relations of reciprocity between the primal germs of her great system?

Our only method of treating this elementary question, (and it is even more elementary than any connected with the ideal development of form, because it demands a cause for the existence of a locomotive force *ab initio,* while the existence of such a force is taken for granted in the abstract mathematical scheme), is to ponder upon the phenomena of electricity and magnetism. We discover in all our experiments of this description, the constant prevalence of the abstract power of *contrariety*, or of opposition. The conventional terms *positive* and *negative*, and of *opposite polarities*, are those of an antagonism. One general notion, as regards all electrical forces, may therefore be applied to elementary ideas in physics; and we may be warranted in speculating, that this *abstract power of contrariety*, as a *primal* cause of physical activity, has its influence in the reciprocal relations of every pair of germs which constitute the poles of each individual ultimate atom, and that it is owing to their elementary *opposite* attributes that any motive energy should be developed in the ethereal substance which intervenes between them. If therefore it be an admitted point of departure in regard to the generation of physical forces, that the *polarity* of each atom is the *elementary* cause of every physical change, we are able to trace up all the progression to an explicable operation of nature, while that operation itself holds an analogy to many others in which *antagonistic* conditions promote physical activity.

Another elementary manifestation of the abstract principle of contrariety appears in our atomic hypothesis, which is almost of a metaphysical, or at least, of a logical character, —because it has to do with problems where Space or geometrical ideas may be considered as mere adjuncts to those connected with Time.

The substance of matter in its ethereal or non-atomic all-pervading state, can only be understood as an *infinitely enduring* Essence, while the period of each atom's *existence*, is in the opposite condition of being limited, or of having a beginning and an end. Therefore the two opposites of the *illimitable* and *limitable* in the abstract, as regards Time, will be perfectly realised in the physical notion of material substance consisting of the *two opposites*, of the *infinitely existing* or *aboriginal ether*, and of the *temporary and spacially limited atoms*. Both with respect to time and space, the atomic "mode of being" is the opposite of the non-atomic mode: this notion is not suggested so clearly when we institute a comparison between the germs of activity, and the passive substance to which they communicate activity,—because both the opposites in that category may not be contraries in relation to Time, although they realise the idea of opposite attributes as regards Space. Should we, however, be able to satisfy ourselves, that the *germs* of the reciprocating polar forces in each atom are *generated beings*, the notion of an absolute contrariety, with regard to their *special* existence and to that of the *general* all-pervading substance upon which they act, may hold its relations to Time as well as to Space.

We have no difficulty in applying the idea of a generative process to the development of the individual atom; but no logical mode of analysis will enable us to determine whether the aboriginal germs, or point-like active entities, (which, by their mutual reciprocity, may concur in the production of the atom), have an eternal existence, or are themselves produced in time. That question seems to be beyond our solution. But mathematically, the *pointlike* germs are the most decided *contraries* of the passive material substance which can be imagined in reference to spacial occupation. The germs do not occupy space, while the all-pervading substance of matter must be *infinitely* extended within it.

Then as regards the nature of the atom itself in the hypothesis, there are grounds for supposing that it partially realizes the idea of an *elementary contrary* bordering upon the highest of all abstract notions, namely, that of "not being," as opposed to "being," in regard to the *absolute* existence of the material substance which pervades Space. For, if the interior of each ultimate atom be an *absolute void*, and the atomic substance be only a superficial shell of agitated and segregated ether, undergoing the influence derived from the magnetic reciprocity of its opposite poles,—we discover the possibility of a physical or *material* "*non-existence*," so far as the occupation of limited regions of space is concerned. This condition is the most decided manifestation of a contrariety that can be conceived by a naturalist; because the *void* thus generated is not the comparative diminution of the quantity of substance which previously occupied a given space, (for no air-pump can cause an absolute void), but it implies the entire and complete absence of material substance.[c]

We have thus seen, that the realization of our most abstract notions of contrariety, so far as they can be made manifest in physics, accompany our efforts to trace up the system of Nature to first principles. *Passive* all-pervading *matter*, and *active forces* promoted by pointlike germs, which do not occupy space *exclusively*, although they must exist within it,—the matter in its aboriginal, or non-atomic, and in its temporary atomic conditions,—the plenary occupation of Space, and the absolute void within each atom,—the manifestation of opposite polarities, even with regard to the two germs which are assumed to be the elementary active entities

[c] The famous tenet of the Pythagoreans, that "the production of *an absolute void* was the first operation of Nature," is surprisingly in accordance with this hypothesis; indeed it seems to be the only method of explaining how such an opinion can have been suggested. If the inductive force could traverse the interior of the atomic spheroid or sphere, it would follow, according to all the known laws of electricity, that the reciprocity between the two aboriginal germs of the primal energy, ought to act *rectilinearly* by the shortest road, and the only comprehensible reason for this not being the direction of its course through the centre of each atom, is the probable non-existence of any material substance within the atomic shell, which is capable of being the medium of a rectilinear reciprocity between its poles, as soon as its lines became curved. It is also an inference, that if the lines which constitute the texture of the shell of each atom, derive their tendency to become more and more curved from *their mutual repulsion*, this assumed change occurs, because each such line is traversed by the reciprocating polar forces, which have no other medium of transfer. Therefore the entire hypothesis accounting for the generation of atoms, cannot be maintained in accordance with the known laws of electricity, unless the interior of each atom be considered an absolutely void region of space, however inconceivably minute such a region may be. It is remarkable, that without endeavouring to reconcile the tradition with the hypothesis which is the basis of our whole physical system, we should practically arrive at the same conclusion as that laid down *doctrinally* by the Pythagoreans, with regard to *the generation of an absolute void* being the primary operation of Nature. In our next section, where the *development of heat* is supposed to be caused by the pressure of non-atomic matter, it will be seen, that any *primal* pressure can only be admissible under the supposition, that the interior of each ultimate atom is devoid of this aboriginal *substantiale* of matter.

that generate the atom, according to our hypothesis—all realise the ancient doctrine of Pythagoras, Empedocles, and even of Aristotle, that the *force of contraries* is essentially powerful throughout the universe, physically as well as morally, and mathematically as well as metaphysically.

SECTION IV.

Hypothesis accounting for the generation of heat.

It has been already demonstrated, that if the aboriginal relation between infinite Space and the homogeneous enduring substance which pervades it, be a *plenitude*, the generation of a *void* within the surface of each atomic individual must have interfered with the " mode of being" of the surrounding non-atomic matter. It would appear, that the material medium in the immediate neighbourhood of the atom must undergo the mechanical process of being *compressed* by the *expanding* void shell, instead of retreating before the protruding surface of the atom without compression,—because it is one of the necessary postulates of the whole hypothesis, that were it not for the generation of the atoms and the existence of bodies composed of atoms, Infinite Space would be evenly and completely occupied by the *primal* or homogeneous matter. Hence the generation of *any* absolute void involves the inevitable consequence of compressibility *somewhere* beyond the surface of the atom. The analogical arguments are in favor of the pressure thus occasioned, being the greatest in the immediate vicinity of each atom, and of its diminishing in proportion to the distance from the surface of the interfering atomic void by which the *ether* is forced out of its place.

Supposing that result to follow, we here find a cause for the generation of actual *elasticity* in the ethereal substance under such conditions;[d] and as all our experiments prove, that the development of heat, or caloric, is the consequence of matter being compressed, we may also speculate upon the probability, that the manifestation of heat would be one of the primary results of the atom being formed. Hence, instead of caloric being a substance, it may be only a *relation* to pressure, as elasticity would be, under the above conditions.

It also follows from this method of reasoning, that the change of form in the atom would be constantly attended by a change in the quantity of pressure and elasticity in the surrounding medium. If each atom gradually expanded from the form of a very oblong spheroid into that of a sphere, (the circumference in lines of longitude being always of the same length), the pressure upon the surrounding ethereal medium would increase until the atom expanded into a sphere, and would afterwards gradually diminish as the sphere became more and more oblate, until it disappeared in its last formal "mode of being" as an evanescent disc: in this case, it is evident, that the greatest effect of the pressure would be contingent upon the *maximum* occupation of space by the void atom.[e]

If the pressure of *non-atomic* matter be made manifest in the generation of heat, we must also suppose that wherever there is an extraordinary interference with the *normal* distances from each other of the constituent molecules of any body, there will be an extraordinary manifestation of heat. Experience in this instance may be cited in support of the general speculation upon the question of the cause of heat: our mechanical compression of any chemical body occasions an increase of its temperature; and the well-established fact

[d] It has been already shown, that the aboriginal material substance in its *normal* state cannot be dilatable, or elastic, although it may be compressible, when acted upon by a compressing cause.

[e] In accordance with this hypothesis, any body whose ultimate constituents are spheres, ought to have the greatest specific heat. It will be found by experiment, that *hydrogen*, which we assume, on other grounds, is composed of such constituents, is precisely that chemical body, which has this characteristic.

of the heat being greater in proportion to the increased depth below the surface of this planet, suggests, that the increased pressure occasioned by its centripetal gravitation, (which is more powerful the nearer it may be to the centre of gravity), has the same effect upon the non-atomic substance intervening between atoms, as that which would be produced by the interference of the ultimate atom itself with the aboriginal plenary condition of the non-atomic ether.

Heat may therefore be attributed to a compression of the ethereal substance in every case. It may be congenital with the formation of the individual atom ; but when atoms become very oblate, and are therefore greatly reduced in size, and when their *individual* and primary compression of the ether may be almost imperceptible to our sensation, which enables us to discriminate between different degrees of heat,—a general compressing force, of a secondary or mechanical character, may make them the mechanical instruments of a pressure upon the ether, which would produce a great intensity of heat. The whole atomic theory is connected with the assumption, that the ultimate constituents of bodies are spheres or spheroids, and that the interstices between them must either be occupied by the *non-atomic* homogeneous substance of matter in its primal state, *or by nothing.* This substance, if it be a reality, must pervade every infinitely minute region of space, except the interior of the atom itself; and as the interstices within a body may admit of diminution by a mechanical pressure of its constituent particles, while this process occasions a development of caloric,—we are warranted in supposing, that the same law is operative in this instance, as when the protruding superficies of each isolated atom occasions the compression of the aboriginal non-atomic substance in its immediate neighbourhood. There are other methods of promoting such an interference with the aboriginal conditions of this substance as will account for the manifestation of heat; electro-chemical action of different sorts, is capable of effecting it; but in every case the ultimate cause of the phenomenon may be traced to the compression of the non-atomic matter, which surrounds and pervades every atomically composed body and every one of its particles.

The inferences deducible from this general conclusion are:

1. That heat is a *relation* to the compression of the material substance which, in its non-atomic state, pervades Space and occupies the interstices of all atomically composed bodies; and that it is an erroneous doctrine, to maintain that heat is itself imponderable matter.

2. That where there is no interference with the aboriginal or normal condition of the ethereal substance, there is no heat, because the substance of matter is then at its *maximum* of dilatability.

3. That our idea of *cold* is one of comparison, as regards the greater or less manifestation of heat, or of the actual compression of the non-atomic substance; and that it is therefore a secondary relation depending upon one which is primary, since heat itself is only a relation to physical activity.

Should these inferences be correct, it is evident that the supposition about Space itself having a specific temperature, or being pervaded by a certain specific proportion of heat, must be altogether unfounded. There may be other consequences of the compression of non-atomic matter, than that of the production of caloric; and various sorts of electrical and magnetic forces may be thereby made apparent. But there is every ground for assuming that the generation of what we call heat, is one of the first results of the automatic formation of the ultimate atom, and that it must be developed, even if only one solitary atom were generated in the infinite expanse of Space. The first manifestation of pressure, of elasticity in the substance compressed, and of heat, would therefore appear to be congenital with the phenomenon of *any* formal change in the condition of the universally extended ether.

Heat, according to this hypothesis, cannot be generated without pressure; and we may conclude, that when it appears to be promoted by the direct influence of the Sun upon the earth, its *immediate* cause is some change in the *terrestrial* atomic matter, or in the closer contiguity of the Earth's component molecules, which increases the pressure of the *non-atomic* substance between them. The remote or exciting cause is undoubtedly *an inductively promoted influence,* depending upon the mutual reciprocity of the two distinct heavenly bodies in question; and this inductive action of the matter of the Sun upon that of the Earth, will account for the *terrestrial* molecules undergoing relative *spacial* changes.

The normal pressure produced by centripetal gravitation must be very low in the upper regions of the earth's atmosphere; because there is perpetual snow on the highest mountains even under the equator, although they are daily exposed to the action of the sun's rays. If we had no other evidence against the supposition, that the solar ray communicates heat either as imponderable matter, or as a *direct* and simple influence,—this one fact would suffice to prove, that where the centripetal gravity of the atmospheric molecules is less than a certain definable quantity, the *direct* influence of the Sun is incapable of liquefying frozen water.

Still, in thus accounting for the origin of heat, and attributing it to the pressure of *non-atomic* matter, we cannot deny, that the substance of this ether throughout the solar system is interfered with by the existence of so large a congeries of atomic matter, as that which constitutes the body of the Sun. The pressure in his immediate neighbourhood must be immense; and independently of the heat which is *indirectly* promoted by the *inductive* action of his rays upon the surface of the planets, there must be a constant cause for a certain degree of heat throughout his system, which is specifically greater or less in relation to the distance from his surface. This constant heat, however, must be secularly diminishing within his system, if all the atoms which constitute the Solar mass be undergoing a gradual diminution in size, and if the *primal* cause of heat be the existence of void spaces within atoms, as has been suggested in our preceding pages.

Supposing the theory of La Place to be correct,—the space occupied by the body of the Sun must have formerly extended beyond the orbit of Uránus; and his interference with the normal condition of the surrounding ether may have then been many million times greater than it is at present. Upon the same principle, the existence of the Earth must interfere to a limited extent with the ethereal or non-atomic substance between the Earth and the Moon, independently of the pressure occasioned by the Sun throughout the general system.

All these questions are fruitful subjects for speculation; and when maturely considered, they may tend to confirm the opinion, that the *primal* cause of heat is altogether *mechanical*, although inductive reciprocity may be much concerned in its development, when the rays of the Sun act powerfully upon the planetary surfaces.

Even if one solitary atom were developed in any region of space, without reference to other atoms, or to those reciprocating forces of corpuscular attraction and repulsion, which must depend upon the existence of two or more individuals,—the pressure of the non-atomic medium might act where there was no manifestation of the forces of mutual attraction or repulsion, because the presence of a single atomic void in the medium of an all-pervading substance must interfere with the plenary occupation of space. It is for this reason, that the generation of physical pressure and of heat, may be assumed, in our analysis, to hold a *relative priority* to that of gravitation in the gradual manifestation of the system of Nature; for physical pressure would be congenital with the formation of each individual atomic entity, while there could be no mutual attraction or repulsion of atoms unless there were at least two distinct atoms in existence.

SECTION V.

On the first conceivable development of physical LOCOMOTION.

In our hypothesis accounting for the generation of the atom, there is the development of two sorts of locomotion. The lines, supposed to constitute its texture, are imagined to have a locomotive tendency which is made manifest in their mutual *repulsion ;* and the poles of each atom are assumed to be constantly approaching each other.

When we reflect on the various modes in which locomotion occurs in Nature, we find that they may all be classed under the two distinct categories of changes of place produced by,—

1. Reciprocal attraction or repulsion, which may be called *electrical* forces.

2. Impulses communicated by the influence of bodies pulling or pressing each other, which may be termed *mechanical.*

Both classes of force may be concerned in the generation of the atom, the one occasioning the mutual repulsion of the lines of its shell-like texture,—the other shortening the common chord of these lines, to each end of which chord one pole, or original germ, of the atom is permanently attached. The locomotion of the atomic poles, in accordance with our surmise, would be occasioned by a secondary *mechanical* force having the attribute of *pulling*. But as the other class of force, or that of *electrical* repulsion, is the prior cause of the mechanical approximation of the atomic poles,—the elementary problem suggested is, *how* may this repulsive energy be generated ? The solution of the question can only be attained by meditation upon the known or inferred phenomena of electricity, and by a careful method of analogical reasoning.

It has been clearly established that every galvanic or electric current promotes a contingent or secondary current, which acts at right angles to its own direction; and that the second current may generate a third, the third a fourth, and so on. This system of generation in regard to contingent currents may be so extended, that it is difficult to imagine any limit to the series. The passage of a current of voltaic electricity generates one of magnetism, which in its turn produces another; experiments have been made, in which this series of currents depending upon others, have been extended to four or five stages, the direction of the new force being always at right angles to that which occasions it, and the poles being always reversed.

It has also been ascertained that the peculiar magnetic power of each such generation, (if the term may be used) differs from that of its immediate parent force. The primary current of voltaic electricity does not act upon the nerves of the animal body, so painfully as the induced or magnetic current which is immediately occasioned by it; and a perceptible sensation may be appreciated *physiologically* in the third or fourth stage, when the most delicate needle is hardly affected by the operation.

The general inference is, that inorganic substances are more influenced by the simpler and earlier species of electrical forces, than by the more compound, and that the highest sort of magnetism is a force which has no power upon the magnetic needle, although it affects the animal nerves of sensation. Many interesting experiments can be considered in detail hereafter, in relation to that delicate branch of electrical science which is connected with physiology. We may, however, at once arrive at the conclusion, that as the most simple electrical forces are the earliest of a series, the aboriginal influence which promotes the *first* manifestation of activity in Nature, is the most simple of them all; and that its immediate and direct effects upon material substance are of the least complicated character.

It may exist as a current which agitates lines of non-atomic matter, but does not impart to them the properties of mutual attraction or repulsion, as a *direct* or immediate consequence of its activity. Such results, however, may be the *indirect* consequence: a *secondary* series of currents may be induced by the passage of the first, and they may be the *immediate* causes of the lines in the atomic texture repelling each other and becoming curvilinear. The common ends of all the lines (or the poles of each atom) would in such a case be *mechanically* drawn together, as the lines themselves become more and more curved. We may thus understand that the force of *attraction* is not requisite in the process accounting for the generation of each atomic individual; the only *electrical* locomotive tendency necessary to this end, being mutual repulsion. But it is impossible to explain the mutual approximation and cohesion of two or more atoms, unless we resort to the agency of an *attracting* force.

Now if we apply the analogy derived from our electrical experiments to its full extent, we must suppose that the currents occasioning the mutual repulsion of the lines in the texture of the atom, which act *laterally* or at right angles to its poles,—are themselves the parents of another species of electrical force, which acts in an opposite direction, or *longitudinally* as regards the poles of the atom. But according to our basis principles, we cannot confound these *tertiary* currents, (or this third generation in the series of forces,) with the *primary* interpolar currents which caused the development of the lateral force of repulsion, although the first and the third sorts of electrical influences thus hypothecated, both act between the poles of the atom. We must suppose, on the contrary, that they really occupy different localities, and that the tertiary currents pass through a layer or pellicle of the ethereal substance which immediately surrounds the atom.

Then, as our first idea of any *difference* between the aboriginal substance which pervades space and that of the atom itself, depends upon the existence of the *primal* current or reciprocity,—we may infer, that this *tertiary* class of agitating force endues the pellicle of ether upon which it acts, with peculiar qualities determined by its own more complicated character. Hence the conjecture, that every atom consists of *two* shells, one internal, or the basis of the atomic individual,—the other surrounding it like an atmosphere, each differing from the other in accordance with the difference between the electrical forces which give their substances a sort of vitality.[f]

Advancing in the application of our analogies, we may suppose that every individual atom or combination of atoms, which has its distinct individuality,—be it a penultimate particle of a simple or compound chemical body, or an entire heavenly body—is surrounded by a *general* pellicle or atmosphere of *non-atomic* matter, which is agitated by interpolar currents acting *longitudinally* between the poles. As regards any heavenly body for instance, such *interpolar* currents may be generated by lateral currents; and these lateral currents may derive *their* origin from a more simple force, occasioned by the aggregate of various electro-chemical processes which are going on between the different *polarized* constituents of the whole body. Ampère's theory of terrestrial magnetism is founded upon a similar doctrine. Every ultimate or penultimate molecule of matter may be considered a complete magnet.

It seems probable, that even as regards the hypothetical repulsion between the lines which constitute the inner or primal shell of each atom,—lateral currents act circumferentially around each line, which has its own distinct pellicle of ether,—and that their mutual repulsion is due to a reciprocity between their *secondary interpolar* currents, which

[f] Details upon this hypothesis may be considered in subsequent pages, because it requires much consideration: but we may confine ourselves at present to the mere outlines of the subject, reserving the many suggestions which arise from the analogical method of treating it, until we have taken a general survey of elementary principles in physics.

are the offspring of their *rotatory* currents. Should this be the case, the same cause for attraction and repulsion may be concerned in the primary repulsion of the lines (which are all supposed to be in the same electrical condition, as regards each other,) as that which would account for the mutual attraction and repulsion of entire atoms.

If every rotatory current,—itself generated by a simpler interpolar force,—causes a higher species of interpolar current, we must suppose that each interpolar current, (unless it be the first of the series), generates two distinct species of force,—namely, a new current of rotation and a force of *inductive attraction* or *repulsion.*

Every development of the electrical force, although the term current is applied, must however be considered as a mutual reciprocity of sympathies or antipathies; not as the locomotion of a single influence in one direction. The interpolar force proceeds equally from the north to the south, and from the south to the north,—while the rotatory force acts circumferentially from the east to the west, and from the west to the east,—as regards any polarity.

Our general arrangement of the progression, in reference to the gradual development of physical energy, is therefore as follows:—

1. We endeavour to materialize the most simple idea of a reciprocity between opposites occasioning a change of state in some very minute portion of the aboriginal material substance which pervades Space. This intercourse, if it may be so termed, between the pointlike atomic poles of each atom, gives a distinctive attribute to the intermediate ether, and acts upon its infinitely divisible substance. The result is the development of a force, which, although the parent of all physical forces whatever, is itself neither attractive nor repulsive.

2. We next apply the doctrines of Ampère to the idea of the primal force generating a secondary one in the *ethereal substance* which immediately surrounds each original line of

the skeleton spheroid; and assume that the primary *inter-polar* agitation generates another sort of force or current in the pellicle of ether surrounding each such original line, which acts tangentially to it, and endues this pellicle or ethereal envelope of the line with a *rotating* energy.

3. We then suppose that this rotatory force, acting in both *lateral* directions, generates two opposite secondary interpolar currents, which give a special polarity to the envelope of ether. This polarity is distinct from that of the internal line itself.

4. Finally, it is assumed, that the *secondary* polar currents of each line generate two new species of currents,—the one species occasioning the mutual *locomotive attraction* or *repulsion* of the distinct individual lines themselves, which in this instance are assumed to be mutually *repulsive*, because their electrical conditions are similar;—the other species being the tangential rotatory agitation communicated to the general envelope of ether, which surrounds *all* the lines of the same atom.

Every distinctly subdivided portion of matter is supposed in this hypothesis to have its special polarity, and its two sets of poles,—the one internal—the other of its ethereal envelope. All *inductive* relations are supposed to depend immediately upon the polar forces of an envelope.

The internal polar forces of each line in the atomic texture are treated as aboriginal. The *rotatory* forces of the special envelope of each such line (themselves generated by the aboriginal force), occasion the development of the *secondary* interpolar forces, or those of the special ethereal envelope of each line. These secondary interpolar currents generate the forces of inductive reciprocity, in relation to the other lines of the atom, and make them recede from each other,—because the identity of their aboriginal electricity which emanates from the same pair of germs, renders them mutually repulsive.

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Their secondary interpolar currents also give a general rotatory impulse to a *common envelope of ether* which surrounds them all, and assigns a uniform individuality to the entire atom of which they are the component constituents. Its integrity is completed by the speciality of the general envelope of ether which surrounds it.

The same method is equally applicable to relations between the atoms themselves. If every distinct atom be surrounded by its pellicle of ether which is agitated by the *rotatory influence* derived from the polarity of the envelopes of the lines composing its texture, each atom must have its *secondary polarity*, which depends upon the general rotatory agitation of its complete envelope. This secondary polarity of an entire atom may be supposed to have the faculty of generating the two species of forces already attributed to the rotatory currents of each of its lines,—namely, an inductive attracting or repelling force, in relation to other atoms,—and the general rotatory agitation of the pellicle of ether which may combine it and the other atoms with which it coheres, in one distinct *individual particle.*

It is in this class of general interpolar currents that we first find the probable cause of the locomotive energy which, under specifically defined control, promotes the phenomena of cohesion, centripetal gravitation, all the varieties of elective affinities, the movements of the heavenly bodies, and every sort of magnetism, be it physical or physiological.

Of course, there must be as many orders of magnetic currents, as there are sorts of phenomena in Nature ; it is not intended to affirm, that the magnetic currents which direct the relations of simple ultimate atoms, although they belong to the same class, hold the same specific rank in the great system of Nature with those which promote the higher physical or physiological phenomena. But it is a deduction from the above mode of reasoning, that the external attractive or repulsive influence of every aggregate of atoms, in whatever stage of complication it may be, must depend upon the existence of a common envelope of *non-atomic* matter, which intervenes between it and the general substance beyond. Newer and higher sorts of physical reciprocity may be developed, where the combination is more complicated; the highest may be supposed to belong to the general aggregation of various sorts of substances which constitute any distinct heavenly body; the lowest may accompany the physical process which occasions the development of the *ultimate atom*, or the primal segregation of a very minute part of the universally pervading homogeneous substance which occupies Space. *Every individual portion of matter may, however, be called a magnet,* and may hold its own special reciprocal relations to other magnets.

The whole system of Nature is, therefore, according to this speculation, a mighty scheme of magnetic relations, exhibiting as many degrees or stages of reciprocity as there are different sorts of individual physical entities in the material world: and the magnetic force of inductive attraction or repulsion may be considered as the *immediate* cause of all physical locomotion.

In concluding this section upon the hypothetical generation of each ultimate atom, and the development of locomotive relations between atoms, or individualised combinations of atoms,—we must bear in mind that there are at least three distinct orders of laws which prevail in the phenomena of chemistry and astronomy.

1. The general dynamical and statical laws of gravitation which depend upon two elements of computation, namely the aggregate *number* of the atoms constituting each combination, whatever may be its complicated character,—supposing, as we are warranted in doing, that every ultimate atom has the same weight, in relation to others; and the greater or less *distance* between such combinations.

2. The special *numerical* and *formal* laws, which determine the number of ultimate atoms combined in the *penultimate particle* of any given chemical body.

3. The *quasi-intellectual* laws of *elective affinities*, which control and appropriate the general laws of magnetic reciprocity between chemical bodies. They suffice to account for all the perfectly regulated changes in the constitution and mutual relations of distinct magnets, whether they be the penultimate cohering particles of a simple chemical body, or the complicated sidereal masses of matter which move in Space—approximating and receding from each other in orbitual paths, in accordance with their relatively varying electrical conditions, which never admit of their cohesion.

SECTION VI.

On the union of atoms in the ultimate molecules of different sorts of substance.

THE excessive minuteness of the ultimate constituents of every material body (supposing them to be atomic individuals which have a defined form) renders it impossible that they can be appreciable by our senses, and chemical analysis will only suggest the relations of size which they may hold to each other. The smallest perceptible portion of any simple substance may contain many millions of distinct atoms.([g])

([g]) It was an opinion of Sir H. Davy, that hydrogen, judging from its peculiar chemical properties, "approaches nearest to what elementary substance may be supposed to be."—*Elements of Chemical Philosophy*, *page* 481.

In the present essay it is assumed, that every atom is undergoing a very gradual or secular diminution of its volume, while its weight in relation to other atoms remains unchanged, —and that when it is at its *maximum* of size, it is a constituent of hydrogen, because that substance is a practical representative of the idea of unity in the general system of chemical equivalents, if allowances be made for the spaces occupied by the interstices between atoms which are in contact under variable conditions.

Dr. Wollaston (*Philosoph. Trans.* 1813, p. 51) supposed that some atoms may be spheres, while others are oblong or oblate spheroids; but according to the hypothesis now submitted to

The practical chemist, however, is able by his analytical skill to effect such changes in the constitution of bodies, that he can determine these relations with great exactness, when he bases his calculations upon certain postulates, which are almost universally admitted. As equal bulks of the same sort of substance, when in the same state, have the same weight, he is justified in assuming that all the ultimate molecules of any body have a similar gravitating property; and by fixing upon any one substance as a standard of weight, he can construct a scale of specific gravities, in which all substances occupying a similar region of space may be arranged according to their weight.

Water is the substance which has been the conventional standard of weight since the days of Archimedes. But as water is itself a chemical compound, every molecule of which consists of two different simple sorts of matter, having uniformly different specific gravitics, either of them may be selected as a standard. It has been determined by accurate investigation that the oxygen in any given quantity of water weighs eight times as much as its hydrogen; therefore, if we multiply the number which denotes the specific gravity of any other substance by *nine*, we transfer the specific relation from water to hydrogen.

Hydrogen is the least heavy of all known substances, and *if it be admitted that every individual atom has the same quantity of gravitating energy*, it follows, as a necessary consequence, that the greater weight of other bodies is occasioned by each of their ultimate constituent atoms being smaller than those which compose hydrogen. *Fourteen* atoms of nitrogen, or *sixteen* of oxygen, ought, there-

the reader, the *oblate* spheroid is the form of the atom in every chemical substance except hydrogen (the ultimate constituents of which are spherical), while the *oblong* form is imagined to have been that of every atom in an earlier stage of its existence, before it was capable of cohering with other atoms, or of being a constituent of any chemical substance.

fore, to occupy the same space as *one* atom of hydrogen; this conclusion, however, offers no idea of the *absolute* size of any single atom in a given aggregate of hydrogen.

But the analysis of compound substances, in which simple elements are always found combining with each other, in some definite proportion *as to weight*, suggests that primitive atoms themselves are so combined; we must therefore suppose that no elementary body (unless it be hydrogen) can exist in the condition of individual atoms; but that the ultimate molecule of every other elementary substance is an aggregate composed of a certain number of atomic individuals, each of which is smaller than the atom of hydrogen. *Hence it would be incorrect to call these ultimate molecules atoms, and to attribute to them the form which may belong to the atom itself.*

For the sake of perspicuity, let us term the molecules of homogeneous substances, *particles*, while such ultimate aggregates of dissimilar particles, as molecules of water, or of any other compound body, may be called *corpuscules;* and let us admit that both particles and corpuscules may be simple or compound.

Now, although according to this method of making hydrogen a standard, we may be able to determine approximatively, without the aid of chemical analysis, upon the *relative* number of atoms which constitute any body, if we know its specific gravity as regards water, it will be a much more difficult task to fix upon the exact quantity of atoms which cohere in the ultimate molecule or particle of any given single substance. This can only be ascertained by analysis; and as it is one of the conditions of the problem, that our powers of analysis cannot break up the *ultimate particle*, the obvious mode of arriving at this knowledge is to compare the results of several analytical processes, by which we separate the particle in question from the other simple but *dissimilar* elements of the corpuscules, in which they are combined; when this is done, a doubt may still remain in our minds whether we have succeeded in ascertaining the lowest number of atoms, whose combination determines the particle. The renewed corrections of chemical tables of equivalents, in which an ultimate particle is often denoted by a lower number than that previously attributed to it, should teach us to be cautious about assuming too hastily that such or such a quantity of atoms is the equivalent number of a simple substance, even if we find it repeated in an entire series of combinations. Let us apply this remark to the ultimate particle of oxygen, the equivalent of which is generally assumed to be *weight.*

The corpuscule of water has been determined by analysis to consist of two equal measures or volumes of hydrogen, and one of oxygen. If we believe that it is a compound of *one particle* of oxygen, and of only *half a particle* of hydrogen, such a mode of computation is hostile to the idea of a particle of hydrogen being the realization of the chemical unity; because we must abandon the scheme of referring to hydrogen as a standard, if its particle be capable of division. On the other hand, if we suppose the particle of oxygen to consist of *sixteen* atoms, which is the equivalent indicated by its relation of weight to hydrogen, we cannot treat the oxygen in the corpuscule of water as a single particle.

The analysis of atmospheric air presents us with another equivalent for oxygen: for a single corpuscule of that substance must be assumed to consist of *fourteen* atoms of nitrogen, and of only *four* atoms of oxygen.

Now, if we compare the corpuscules of water and those of air, we discover that although the *ultimate* equivalent of oxygen may be *eight* in one instance, *it is four in the other*, while its weight, in reference to the common hydrogen standard of unity, is *sixteen.* Hence we arrive at the inference, that the ultimate molecules or particles of oxygen can only equal, *in bulk*, one fourth of those of hydrogen; and we may conclude that the corpuscule of water consists of one particle of hydrogen and two of oxygen; while that of air is a compound of one particle of nitrogen, and one of oxygen; *four*, therefore, ought to be the equivalent of oxygen.

The same reasoning is still more applicable to those simple substances, which are connected in chemical tables of equivalents with such high numbers as fifty or a hundred.

It has long been a question with natural philosophers, whether there is any absolute or permanently indissoluble *cohesion* between the *ultimate constituent molecules of bodies.*

Practically, there is every reason for believing that the *ultimate* atoms which constitute each *penultimate* particle of a *simple* chemical body, are united in so compact and permanent a manner, that they resist all known modes of disjunction; and as the specific characteristic of every substance depends upon the union of molecules according to fixed laws of *number*, it is evident that the annihilation of the characteristic of a body must be the result of any interference with its special proportional conditions of aggregation. The decomposition of *compound* substances by chemical analysis, interferes with such conditions of proportion. The molecule of water, air, or any other *compound,* ceases to exist, when the constituents of each such molecule are so separated, that the special numerical law of proportion cannot exert its influence. In such a case there is no doubt about the *cohesion* between the particles of oxygen and nitrogen, or oxygen and hydrogen, being the *temporary* result of an attractive force.

Again, as regards the more general sort of cohesion which occasions the existence of bodies composed of an indefinite quantity of similar molecules, be such bodies simple or compound, cohesion may be interfered with by the application of heat: and the three distinct conditions, of solidity, liquidity, and vaporisation, imply that there can be no absolute contact between the molecules thus apparently in cohesion.

But the question with which we have to deal, is, whether each *penultimate* particle of a simple chemical body (which particle consists of a specific number of ultimate atoms), is so constituted, that these atoms always cohere, and that however the distances between the *penultimate* particles may be changed by chemical processes, the union of the *ultimate* constituents *in each particle* cannot be interfered with, by the application of heating or cooling processes. All *primâ facie* argument supports the hypothesis, that when bodies are expanded or contracted by an alteration in the heat by which they are affected, their *penultimate* particles remain *individually* in the same state, and that the *cohesion between the ultimate atoms composing each distinct particle, undergoes no change.* Should this be correct, our most elementary idea of cohesion is realised in the existence of the *penultimate* particles of simple chemical substances; and it is evident, that, notwithstanding our analytical processes, we have not yet succeded in annihilating the specific characteristic of any simple chemical substance under investigation, or in dividing the *penultimate* molecule, as we can the body, by any method of disjunction.

Our only theoretical mode of accounting for the automatic formation of the specific penultimate particle, and for its dissolution, is to suppose that ultimate atoms which change their individual forms, change their relations to each other; and if we assume that each atom was generated independently of others, there is no other method of explaining why they are in contact or *quasi-contact* in specific penultimate molecules, than that of supposing that when they attain suitable forms relatively to each other, they not only approximate, but cohere in groups which are determined by chemical laws in regard both to the number of atoms in each group and to the formal mode of their arrangement.

Cohesion, or apparent cohesion, is therefore the first condition of attraction observable by the practical chemist; and in accordance with the doctrine that every simple substance is incapable of change, the constituents of each *penultimate* particle should have all the attributes of the *ultimate* atom, which he supposes to have been always such as it is at present. When this doctrine is insisted upon to its full extent, we may understand why the notion of *penultimate* particles will not be popular until it is examined analytically, and considered in relation to first principles and to our elementary ideas of form.

The hypothesis submitted to the judgment of the chemical reader, is based upon the supposition that the existence of every simple and every compound substance depends upon the agglomeration of constituents,—that the same rule prevails, whether the body under consideration consist of similar compound corpuscules, each of which is composed of dissimilar simple particles,—or of similar particles, each of which is a combination of similar ultimate atoms. The *compound* corpuscules may be separated by practical analysis, but the *simple* particles resist this artificial mode of dislocation ; still, as there is no irrefragable cohesion either between the compound corpuscules of water, or the simple particles of a gaseous body, we might at first infer that the ultimate atomic constituents of any particle in a simple body, are not in absolute contact, although they resist our artificial methods of separation.

Our hypothesis supposes, that there is an inherent tendency in every atom to change its form,—the polar diameter decreasing, while the equatorial diameter increases.

The period of time occupied by the general process which would at length convert a hollow sphere into a superficial disc, may be immense, and the fractional parts of that period, in relation to the smallest perceptible alteration of form, may require millions of years for its completion. Therefore it is impossible that human observation could ever record events which have resulted from the secular contraction of the same constituents of a particle. But in chemistry, as well as in zoology or botany, we may observe different combinations and forms, which suggest the idea of atoms in various stages of such a progression; and we may infer that there is a necessity for the existence of regulations, which would determine the mode in which the change is to operate in Nature.

It has been already observed, that *occasional* alterations of bodies, which may be immediately converted from solids into fluids, and from fluids into gases (or *vice versâ*), exhibit such bodies under different spacial conditions, and suggest an analogical method of solving the problem. We find fixed points in a thermometrical scale, which determine the absolute *end of one state of being* of a substance, as regards its occasional changes of form and bulk, *and the beginning of another*: we may therefore surmise, that when the *secular* contraction reaches a certain point, the particle whose atoms are thus contracted, undergoes some change in the number and arrangement of its constituents: and this harmonizes with the notion, that the ultimate atoms of all heavy substances formerly constituted the particles of those which were lighter.

But no *artificially-promoted* change in the *formal* relations of the contiguous particles of a liquid body will lead to further consequences than the production of the frozen state on one side, or that of the gaseous state on the other. So far as has been yet ascertained, we can neither break up a penultimate particle, nor make a new one, by any known method of increasing or diminishing the heat,—that is to say, by increasing or diminishing the elastic force of the ether which pervades all substances; and this impossibility is equally apparent, whether we attempt to increase its elasticity by adopting an electro-chemical mode, or by resorting to the agency of mechanical pressure.

Every substance vaporizes, melts, or congeals, at some fixed thermometrical point, due regard being had to the atmospheric pressure in the locality where the change may occur. This fact suggests an idea of the prevalence of some great law, which determines that *all* physical changes should occur *suddenly*, notwithstanding the graduated approach towards limits, which is shown in the interval between the freezing and boiling points of substances on a thermometer.

We know, for instance, *by experiment*, that the gradual addition or abstraction of heat to a certain point, will warm or cool water without converting it into steam or ice; and infer *theoretically*, that the increase or decrease of the elasticity of the ether between its *penultimate* particles or corpuscules, may be the causes of the change which operates in extending or contracting the ethereal envelopes surrounding each particle or corpuscule until the mass to which it belongs, freezes or vaporizes. But we are precluded by all our preceding arguments from believing that the constituents of the penultimate particles themselves undergo any change of bulk, whether the substance in question be gaseous or liquid. This remark applies with more complete accuracy to mercury or any *simple* body, than to water, which consists of *compound corpuscules.*

If, however, we suppose that the general law of *sudden* changes governs the alterations in the form of the outline of the ultimate atom, as well as of the particle, we cannot reconcile such a notion with the assumption that each atom undergoes a very slow but continuous alteration in its shape and bulk, unless we imagine that there is a balance between the changes of the *internal* and aboriginal substance of each atom, and those of that *external* envelope of ether by which it is surrounded. When we assume, that the envelope of each distinct ultimate atom consists of a fixed and definite quantity of ether during the whole period of its existence as an individual, it follows as an inevitable consequence of such a supposition, that while the *internal* shell of the atom is expanding, the thickness or depth of its envelope must be diminishing, and *vice versâ:* and if it be supposed that the depth of the envelope is not the same in every circle of latitude, unless the internal shell be a perfect sphere, there is no difficulty in accounting for the absence of any *external* change of form in the outline of the envelope, while its own internal concavity, and the external outline of the aboriginal texture of the atom itself are undergoing a continuous change, —until such an addition has reached a certain fixed *limit*, beyond which the balance of adjustment between the outlines of the two shells cannot be maintained, without altering the *outline* of the atom's ethereal *envelope.*

Hence it is possible to conceive a condition of the ultimate atom, in which the aboriginal or internal texture is undergoing a continuous change of outline, while the envelope upon which its combination with other atoms depends, preserves the same form and absolute bulk until the *continuously* acting internal change has reached the climax, beyond which the balance cannot be sustained without affecting the size and perhaps the shape of the external envelope.

When we review the whole argument, we find grounds for supposing,

1st. That the generation of the atom makes it manifest at first as a spheroid, so excessively oblong, that it is almost a straight line,—that it gradually expands, until it becomes spherical,—and that the same electro-magnetic repulsion which produces this change of form, is the unceasing force which eventually converts it into a superficial disc.

2ndly. That as regards time, the period occupied by the secular expansion may be equal to that occupied by the secular contraction; and that the cohesion of atoms in fixed proportions as the constituents of a penultimate particle, does not occur until the atom contracts, and ceases to have a spherical form.

3rdly. That hydrogen is composed of molecules, each of which may be a single atom having a spherical form; and that, therefore, atoms of hydrogen may hold an analogy to the *penultimate particles* of other simple bodies, and may only be in contact *provisionally*, which is not the case with single atoms in any other simple substance. It follows, that hydrogen may be the only simple cohesive substance which must be always in a gaseous state.

4thly. That when atoms had expanded to their maximum, and became spherical, the first development of an *attracting* force was made manifest in the production of hydrogen.

5thly. That there are two sorts of *cohesive* forces in chemistry,—that which promotes the formation of bodies by uniting particles *in indefinite quantities*,—and that which is made manifest, when a *definite number* of atoms are combined in the *penultimate* particles of simple substances: but this last process does not occur until the atomic constituents of the penultimate particle have attained a certain degree of oblateness.

6thly. That the spherical atoms, each of which is an *ultimate* particle or molecule of hydrogen, may be separated from each other by a mechanical force, or by the analytical processes of chemistry, as the *penultimate* molecules or particles of any other chemical substance may be; but that no cause is adequate to the disjunction or separation of the atomic constituents in any penultimate particle of any other simple substance, unless it be the gradual increase of the oblateness in each atom composing it; still, that this gradual change of form is an inevitable necessity as regards *every* existing atom after it has attained its spherical condition.

When we meditate upon these general physical assumptions, we cannot avoid speculating, that if the *oblong* spheroid be the form of the atom during one half of the period of its existence, it must have some peculiar qualities when it is in that state; and that, according to the general analogy, such properties ought to be the *opposites* of those which are attributed to it by chemists.

The opposite of cohesion is dispersion, and the discovery of the general class of substances, called *ozone*, may lead to most important results in regard to the qualities of *different classes of oblong atomic spheroids.*

It is evident that all substances which are composed of atoms, or of aggregates of atoms, consist of parts having interstices between them. But these spaces may confine a certain definite quantity of single *unconnected* oblong spheroids, holding a fixed relation to the quantity of *oblate spheroids*, of which the body in question is composed. And as bodies must consist of many distinct atomic aggregates, and most probably of layers of such aggregates, the phenomena of saturation may depend upon the occupation of the interstices between the layers. Hence it follows, that when bodies are broken up by mechanical force, or chemical analysis, many confined *oblong* atoms would be liberated; and if they had *repulsive* relations to each other, they would appear to *radiate in space*, as odours or scents do, so long as they were moved by this *mutually repulsive* energy.

SECTION VII.

On the distinction between the inductive *and* conductive *transfer of electrical forces.*

The terms of *induction* and *conduction*, constantly employed by electricians, are too often used vaguely and without sufficient distinction between these opposite, or at all events dissimilar modes, in which electrical influences are communicated, in the processes of Nature. This confusion arises principally from the fact, that a *limited inductive* influence is in operation within the limits of every distinct heavenly body, and that all our electrical experiments must be made within such an arena.

The clear theoretical distinction is, that where the reciprocal influence between non-cohering individuals (be they heavenly bodies, individual atoms, or even the pointlike germs which are supposed to become the opposite poles of each atom) is propagated sympathetically through a medium of non-atomic matter, it is *inductive;* but that when the influence is transferred from one individual body to another *cohering* or in contact with it, the process is called *conductive.*

The popular notion of induction has been suggested by the following simple experiment. If a body in its normal state of electricity be placed within a certain distance of one which is highly charged, without being in contact, the relatively *negative* body will immediately exhibit proofs of a change having taken place in its own electrical conditions, which cannot be accounted for by any process at all resembling the withdrawing a portion of the surplus electrical force from the *positively* charged body; because their being subsequently and suddenly removed from each other's neighbourhood will occasion as sudden a disappearance of the temporarily induced state of the one whose normal or statical electrical equilibrium was disturbed by the contiguity.[h]

[h] Professor Faraday has detailed some interesting experiments upon "static electrical *inductive* action," in a memoir first published in a letter in the *London and Edinburgh Philosophical Magazine* in 1843, and afterwards reprinted in his second volume of *Researches in Electricity*. He found that an insulated brass ball which was positively electrified, imparted a positive influence to the *outside* surface of an insulated metallic ice-pail, within which it was suspended, care being taken that the *inner* surface of the vessel and the ball should not be in contact. When the ball was removed, there was no manifestation of positive electricity on the outside of the metal pail; and when the charged ball was brought *into contact* with the inside surface of the vessel, the charge was communicated from it to the vessel. The same result occurred as in the inductive experiment. He then arranged a series of such vessels (one within the other), their supports being plates of shell-lac, and their sides not being in contact: the electrometer attached to the *external* surface of the *outer* pail was affected by the ball, when it was introduced into the *inmost* without contact, precisely as if there had been but one such vessel.

It is evident, that whether there was one or many vessels, so long as the charged ball was insulated, the *inner* surface of the inmost pail must have been electrified *negatively* by *induction*, through the atmospheric air which intervened between the ball and the inside of that inmost vessel; and that the inside of each pail in the series must have been also *negatively* electrified, through a similar non-conducting medium. As soon, however, as the ball was brought *into contact* with the inside of the inmost vessel, the electrical relative conditions of both its surfaces (and of every other in the series in the compound experiment), must have been reversed. The *inside* of the metal pail which was virtually a portion of the same electrical body as the ball when they were in contact, would become *positive:* the *outside* surface would then be *negative.*

The reason for this is obvious, supposing there be but one sort of electricity in activity in the operation, and that the terms *positive* and *negative* indicate the *opposite* relations of *plus* and *minus*, instead of different species of the electrical force. The results of the contact between the charged ball and the inside of the insulated ice-pail, are precisely similar to those observed in charging a Leyden jar, which is insulated. When there is no apparent conductive communication between the *outside* of the jar and another body, it is only capable of receiving a very low charge; but if we establish such a communication, the jar may be much more fully charged from the conductor of an electrical machine. In some experiments made by the author, this capacity of a single jar for receiving a charge, was gradually increased by successively bringing other insulated bodies into contact with its *external* surface: if the new body was the ball of another jar, the *inside* of that jar became charged with *positive* electricity to a less extent than that of the first jar, but in a proportionate degree to the quantity of the charge in the first: a third and a fourth jar were charged in the same way, but the intensity of the charge in each jar was less in proportion to its distance in the series from the conductor of the machine.

The important inferences suggested by such experiments are:

1. That except in the instance of the first jar, the charge was commu-

The highest sort of electrical or magnetic induction may be supposed to prevail, where the interval between

nicated through glass, and that although all the results were the same as those of the transfer through the metallic substance of the ice-pail, yet each jar retained its charge when removed from the neighbourhood of the others. This could not have occurred, if the charge had been communicated through the glass by *induction*. Hence it follows, that the *insulation* of any component body of this planet, can only be relative to some degree of the *non-conductive* quality of the atomic matter which intervenes between it and another body,—and that no substance which comes under our observation can be *absolutely* a non-conductor, unless it be the ether which pervades space and intervenes between heavenly bodies. If a highly charged body be within a certain distance of one not charged, it may impart a *conductive* quality to any medium composed of atomic matter between them, which in ordinary electrical terms is called a non-conductor; although, if the charge be feeble, the insulation is complete, and the only observable effects of the proximity, will be the *temporary* phenomena of induction. It is evident, that the limit between conduction and *induction*, as regards substances used as insulating media, holds an analogy to those between vaporization, liquefaction, and solidification. A special limit is assigned by Nature to each substance, distance being also an element in the consideration. The more remote a charged body is from one uncharged, the less likely is the medium which insulates them to be a conductor; therefore, the intensity of the electric charge and the distance must both be taken into account. The great test of the conversion of a non-conducting substance into one which conducts, is the *permanency* of the abnormal condition in the body which is affected by the proximity of another. Whether a substance be a good or bad conductor, or a good or bad insulator, must depend upon *its peculiar aptitude in relation to the intensity of the electric force* which acts upon or through its medium.

2. That in the transfer of electricity by *induction*, there can be no accumulation of that influence which induces a disturbance of the normal electrical equilibrium of the affected body, because the removal of the exciting body causes the cessation of the abnormal polarization in the other. But in the case of a *conductive* transfer of the influence (proved to have taken place by the *permanency* of the abnormal condition of the affected body), the process appears to be an *increased antagonism* in the existing distribution of the so-called electric fluid or influence, which was previously attached to it,—a more decided opposition in its negative and positive poles,—in other words, a higher species of polarization, which is permanently attached. In cases of *conduction*, the one surface of a jar is negatively electrified, when the other is made positive, not by a mere unequal distribution of its own *statical* electricity as in the case of induction, but by an excess communicated to one of its sides or poles from another body, which cannot occur unless a corresponding quantity of electricity be transferred from its outer surface, or other pole, to a *third* body. Although this conductive transfer (which suggests the idea of a current), has the same polarising result, as mere proximity in the simple inductive process, the existence of an *absolute transfer* is most probably the cause of the disturbance of the normal equilibrium being permanent: but such an explanation militates against the doctrine, that even in the case of conduction, there can be any excess or accumulation of electricity in the whole body.

the reciprocating bodies is wholly devoid of all atomic impediments, and only occupied by the primal ether or non-atomic substance. This, we assume, occurs in relation to the original formation of the atomic embryo, when it has the form of a straight line between the two point-like germs which are afterwards its constant poles. But as our powers of observation will never enable us to perceive the operation of this first hypothetical process, we can only observe its analogue in the effects which it occasions in astronomical phenomena, where the same sort of non-atomic medium may be presumed to exist between distinct heavenly bodies. It is true, that induction is made manifest between bodies within our atmosphere; but although the non-atomic substance which constitutes the envelopes of atoms and their combinations may admit of its propagation, we can never be sure that the intervening *atomic* matter which must connect any inductively-reciprocating *terrestrial* bodies, is not affected to a certain extent by the process. Notwithstanding the general idea that some bodies are absolute conductors while others are absolute non-conductors,—the whole scheme suggests that this distinction is only relative and not absolute,—in other words, that some conduct easily, while others are *insulators* unless they are powerfully influenced. Still, our observations lead to the belief, that an *inductive* transfer of reciprocity must occur within our atmosphere, which is very little affected by any concomitant *conduction*.

The instantaneous propagation of *radiant* heat through atmospheric air which is hardly warmed by the process, and which if warmed only becomes gradually heated, may be attributed to a reciprocity of this inductive character between two remote terrestrial bodies, one of which being previously heated imparts some energy to the other by an electrical or magnetic sympathy, which is capable of suddenly eliciting the heating tendency in the *inductively*-affected body. The communication of the sympathy evidently depends upon the nature of the medium between the reciprocating bodies.

A due consideration of the phenomena of induction and of cohesion, will lead to the general conclusion that the cohering ethereal envelopes of all molecules of terrestrial bodies, and of such bodies themselves, are permeable by the force of the inductive reciprocity, notwithstanding the non-atomic layers of matter which constitute these envelopes, are in a peculiar state of being, and differ specifically from each other as well as from the general non-atomic medium in which each heavenly body undergoes its orbitual motion. We have already surmised, that every different sort of atomic aggregate, be it simple or compound, is surrounded by a shell of ether having its own peculiar magnetic qualities; yet such differences do not seem to oppose perceptible obstacles to the transmission of the general inductive influence. Where the distance between the nuclei of cohering molecules is small (as must be the case in most solids), the induction would meet with more impediments than where their envelopes were deeper; but in every instance of such a permeability, there must be some impediments, which need not exist beyond our atmosphere.

It may therefore be inferred :

1st. That what is called electrical *conduction* cannot exist, unless there be a connecting medium of *atomic* matter, and that the electrical force passes *conductively* from the envelope of one molecule or body to another,—when their ethereal envelopes are in contact.

2ndly. That the *inductive* influences may be propagated *through the envelopes themselves* in a rectilinear direction, with the rapidity of light. It is also probable that they are capable of being *reflected* both from the outer and inner surfaces of the envelopes, in the same rectilinear manner, the angles of incidence and of reflection being equal; and this would account for substances being permeable by an inductive force, where the impediments to its *direct* transmission are insuperable, in consequence of the thickness of the intervening atomic substance. Such a reflected process of inductive propagation would be more likely to occur in gaseous than in liquid or solid bodies, because the ethereal envelopes of the molecules of a gas are more expanded than those of a fluid or solid substance; and the interfering atomic molecules would consequently interpose to a less extent in the aggregate.

3rdly. That where there is no intervening atomic substance between two heavenly bodies, there will be no impediment to the process of inductive reciprocity between them: and that this magnetic force may be propagated *directly*, as is the case with regard to the inductive influence of the solar beams, or those of the fixed stars, upon the earth,—or *indirectly* by reflection, as happens in the transmission of the light of the moon and planets.

It is evident that, if we admit these doctrines, *light is one of the relations to magnetic induction*, and that its manifestation depends upon laws, which belong to the highest class of magnetic phenomena in which *sensation* is concerned. Physical causes alone are not sufficient to account for *any* sensation. What we call *light* is really the effect produced upon the *sensorium* of an animal through its organs of vision. Many of the *physical causes* which concur in giving us an idea of light, may be generally necessary in the great *inanimate* system of Nature; but that peculiar relation of such causes *to the eye*, which occasions light, may be specially intended as a mode of animal perception, and may have nothing to do with any other operation.[h2]

[h2] Such remarks may appear too metaphysical for an essay on natural philosophy; but they ought to accompany our considerations upon inductive influences, more especially as the idea of *visual perception* and the metaphysical cause of that sort of sensation, are generally confounded with its merely physical causes. Light holds a necessary relation to sight; but to sight alone: without the eye there could be no such perceptible phenomena as those of sight, colours, &c.

The author does not mean to suggest that the phenomena of light have no real existence; but his object is to show, that when light is said to be the cause of certain physical changes, *which accompany*

The completely inductive processes in Nature, are concerned in the greater portion of her operations. The first of these is the presumed formation of the ultimate physical atom, where there is a prevalence of inductive *repulsion*. The next is the manifestation of that *attractive* force between ultimate atoms, which is the cause of their mutual approximating locomotion, or contact and cohesion, as well as of the cohesion of simple particles, compound corpuscules, and bodies, which are the constituents of any connected sidereal mass of such aggregates. Within each distinct heavenly body there is a subordinate manifestation of inductive attraction, which is always subordinate to the principle of centripetal cohesion.

Where centripetal or general cohesion ceases to be dominant, there are three general sorts of induction, which prevail between distinct heavenly bodies.

1. The general force of attraction unaccompanied by repulsion, will account for the tides, and for the separation of portions of any heavenly body from its mass, in consequence of the *external* force of reciprocal attraction between them and *the mass* of any other entire heavenly body, being so great, as to counteract the general tendency of the internal or *centripetal* attraction, which without such an external interference would *permanently* keep together all the individual portions of the same heavenly body, in a general *spherical* form.

2. It is very probable, that every such distinct mass of atomic matter, as a moving heavenly body, derives its orbitual motion from the alternations of attraction and repulsion which depend upon its relations of reciprocity to some other heavenly body, when the laws of electricity determine

its manifestation, a great mistake is made in confounding a cause with a coincidence. The same *general* inductive energy which occasions all optical perceptions, in relation to the eye, may *under other relations* occasion all the physical phenomena attributed to light. But to affirm that the cause of such changes is light, is illogical and contrary to the spirit of elementary analysis.

that in similarly electrical states they should repel, and in dissimilar, they should attract each other.

3. The highest magnetic effects of induction, constitute an immense category or class of processes. Solar heat,—solar and sidereal light, whether it effects our vision directly, or by reflection,—the solar, lunar, and perhaps the planetary influences upon processes of physiological development, even as regards the mental faculties of animated bodies,—may all be the consequence of special inductive reciprocities between the masses of heavenly bodies and distinct portions of their cohering substances, or between the molecules of one heavenly body, and the entire mass of another. This last class of inductive influences, where the intervening space is most probably devoid of all atomic matter which could interfere with its propagation, is so multitudinously divided into orders, genera, species, and varieties, that we can never hope to investigate the whole category of phenomena which may depend upon its prevalence.

SECTION VIII.

On cohesive attraction considered in its various degrees of energy.

If every simple body except hydrogen, consists of specific molecules or *particles*, each of which is a combination of a *definite* number of ultimate atoms, and we are unable to disunite them by any chemical process,—it is evident that the laws which determine the cohesive energy of the mutual attraction of their respective constituents, must differ from that which admits of the artificial breaking up of the constituents of a compound corpuscule. Any such chemical dislocation is really the annihilation of "the being" of the combination. To disunite the atoms or *ultimate* constituents of a simple particle, would be to destroy the *speciality* or distinguishing characteristic of any peculiar sort of simple substance; and if such constituents be afterwards combined under some other condition with respect to number and form, the practical result would be the *transmutation* of simple substances. Whether such changes really occur in Nature, is one of the chemical problems as yet unsolved; but that they might happen, is in accordance with our atomic hypothesis. If each atom has an inherent tendency to alter its form, and continues to undergo the secular change, this would render it unfit for *constant* combination in any given substance, whose specific gravity is a fixed quantity in relation to the space occupied absolutely by its specific particles.

Modern discoveries with regard to what are called *isomeric* substances, seem to suggest, that some such changes may be hastened artificially by the chemist; it is also possible that in the process of physiological digestion, new substances are formed, which have all the attributes of simple chemical bodies. Still, the cohesion of *ultimate* atoms in the *penultimate* particles of a simple substance, may be considered the most powerful manifestation of limited attraction or of a gravitating influence, with which we are acquainted; and it is the first modification of that peculiar electrical force, which is the basis of the centripetal energy, and which acts generally as the connecting tie between all the constituents of the same heavenly body.

The various degrees of cohesion appear to depend upon one general force of attraction, which is modified by peculiar circumstances; and it may be regarded in the same general point of view, as the principle of gravitation in the Newtonian system, where the dynamical laws are not supposed to meet with any interference from those of chemistry and electricity. The centripetal cohesion of all the constituents of the same *heavenly* body, notwithstanding the varieties of their chemical attributes,—and the cohesion of the distinct atoms in the same sort of chemical *particle*,—may be equally attributed to one general sort of force, acting between particles, corpuscules, or various species of chemical bodies, in accordance with general regulations, in which the number of *ultimate* atoms is represented by a *proportional* intensity of the attracting force,

—due regard being had to the relations of distance between the cohering atoms, or between their combinations.

But when we take into account the laws of the great chemical scheme of Nature, we discover causes for an interference with this general method of calculation, as regards the formation of different sorts of particles or corpuscules.

1. The laws affecting *quantity*, which determine the *precise number* of distinct individuals necessary to the constitution of a *particle* of a *simple* substance,—or the precise number of *dissimilar* particles which must be combined in each *corpuscule* of a *compound* substance,—will interfere with the general operation of the force which brings any number of ultimate atoms, or penultimate particles together, in *indefinite* proportions.

2. The law of *elective affinity*, which promotes the breaking up of some corpuscules and the composition of others out of their disjoined particles, when they are submitted to chemical analysis,—infers the existence of a peculiar system of appetency and a *comparative* intensity of attractive cohesion, which is a farther restriction upon the operation of the *general* force of gravitation.

We may therefore arrange that sort of attraction which promotes cohesion, in three different classes.

1. Centripetal or general cohesion.

2. General cohesion governed by the laws connected with a *definite number* of individuals combined in a new individual aggregate, be it simple or compound.

3. General cohesion under subjection to a system of *elective affinities* which need not depend upon numerical influences, but upon some specific forces of a *quasi-mental* character, which almost suggest the idea of a metaphysical power. The chemical and electrical laws, as well as all those which have to do with *ductility* and *fusibility*, cannot

be said to depend upon the weight of substances or their relative specific gravity.

The general principle of cohesion, which may be measured as a simple force in physical dynamics or statics,—although it is evidently the basis of all the varieties of the cohesive force, does not appear to be unmodified in any process of atomic combination: if we entertain any doubt upon this point, it can only be with respect to the first presumed mode of atomic cohesion, which, as has been hypothecated in a preceding page, may occur where spherical atoms are themselves particles, in the case of hydrogen. It is possible that these spherical atoms cohere, upon the same general principle as that which prevails over all the variously-diversified substances of any distinct heavenly body: but as every other simple substance, except hydrogen, is supposed to consist of specific *penultimate particles*, each of which is an aggregate of a *fixed number* of oblate spheroids,—we are warranted in the conjecture, that even the primary process of such a combination is varied, and that each simple substance from the first, depends upon peculiar electrical laws which modify the general principle expressed in usual physical language by the term *specific gravity*. The weight of any substance may indicate the number of *ultimate* atoms, which constitute it,—without justifying the conclusion that it is the measure of the force with which the atoms themselves cohere in its penultimate particles, or with which such particles are attached to each other in an indefinite proportion, so as to present the form of an irregularly-shaped body.

Nevertheless, we may assume from experiment, that the cohesive force of the similar atoms in the *simple particle*, is more intense than that of dissimilar particles in each *compound corpuscule*,—and that this graduated series of intensities in chemical cohesion, holds a relation to the degree of complexity in the body; the *general measure of the intensity* of the chemical cohesive force being the *comparative* simplicity or complexity of the cohering molecules.

It is probable, that the laws of the electrical or magnetic system of nature may be much concerned in the development of the elective affinities of the chemist. A compound corpuscule consisting of dissimilar particles, may be broken up by the peculiar influence of such regulations, when it is exposed to the interference of other sorts of compound corpuscules, and when there is an exchange of their respective particles and a new combination, in consequence of peculiar tendencies which are of the samé special character as those which determine the comparative degrees of ductility or fusibility of various substances, independently of their specific gravities. But we may also suppose, that the cause of the *preference* which one chemical subject manifests, in separating itself from another to unite with a third, may be owing to the greater or less degree of attracting force called into action in such cases: at all events, this comparative power of cohesion may be the instrument which is controlled and used by the special and *quasi-intelligent* energy of magnetic *election*, when such automatic changes occur in the great laboratory of Nature.

Whatever may be our conclusions upon this point, it is evident that the motive force is that of *attraction*, and that we do not require electrical *repulsion* as an agent in the production of the phenomenon. If a corpuscule of water undergoes dislocation, in consequence of the particle of oxygen being attracted by a particle of iron which is oxydised, while the particle of hydrogen, heretofore united with the oxygen, is liberated,—the greater force of mutual attraction between the oxygen and iron than between the oxygen and hydrogen, will account for one sort of cohesion being substituted for the other. In such a case it is not necessary that the interference of the iron should occasion any *repulsion* between the oxygen and hydrogen which constitute the water, although its constituents cease to cohere; the preponderating attraction of the iron will suffice as the *elective* cause of their dislocation.

This inference is important, in relation to our general doctrines about the various degrees of cohesion, which are developed in the automatic agency of chemical affinities: the whole system may depend upon a *comparative excess* of the attracting force; and those alternating energies of attraction and repulsion which are made manifest in our *electrical* experiments, (where, in the language of the electrician, " bodies similarly electrified repel each other, while those which are in a dissimilar electrical state have a mutual attraction") are not necessary to account for such a chemical change as the one referred to. *Why* any two substances should be indued with a tendency to attract each other in preference to all others, is however a problem in physical philosophy, which can only be solved by a much more complicated mode of investigation; and that inquiry may be reserved for a future occasion.

The attraction of cohesion, which is now the subject of our examination, may therefore be considered as a general force, the intensity of which is modified in Nature, either in consequence of the more or less complicated character of the molecules which are united, or of some peculiar tendencies special to each substance independently of the stage of the complication. Both these causes for interference with the intensity of the cohesive force may be in operation simultaneously.

Now, considering cohesion as the most energetic development of attraction, and the opposite of mutual repulsion, we cannot fail to observe that this stage of the force has its beginning and end in the progressive system of Nature. If our speculations about hydrogen be correct, the mutual attraction and cohesion of the particles of hydrogen is the first development of the union of ultimate atoms; and that process is of a transitive character in regard to the *mutual repulsion* of all oblong atoms and the most *intense cohesion* of oblate atoms in the penultimate particles of simple chemical substances, each of which consists of a *definite* number of such atoms. This most intense cohesion is not to be found in the union of the ultimate molecules of hydrogen, if every *ultimate atom* of hydrogen be separable from the body with which it is combined; and if this separation may be effected by mechanical as well as analytical means. But single atoms which constitute *any other chemical substance* are incapable of mechanical separation, and so far as has yet been proved, they resist the analytical efforts of the practical chemist to disjoin them individually from the specific particle in which they are united.

The existence of hydrogen may therefore indicate the first manifestation of attraction and general centripetal cohesion,—but not of specific *chemical* cohesion, the force of which is far more intense than that of the *general* cohesion, because the specific cohesion of ultimate atoms in a penultimate particle only appears to yield to the circumstance of such ultimate atoms changing their form.

In the next section it will be shown, that the centripetal force which binds together the various sorts of substance composing any distinct heavenly body, may not prevent their being separated from it by an external *counter-attraction*. But no observation has ever suggested that any two heavenly bodies are capable of cohering; portions of the same astronomical mass of matter composed of oblate atoms, (and unless they were such, they are supposed in our hypothesis to be incapable of cohesion) when their envelopes are absolutely disjoined, appear to occasion each other's orbitual movement in space in obedience to the laws of electrical alternations of attraction and repulsion; but such a doctrine deprives them of *mutual cohesive* tendencies. Hence we presume that cohesion has its limits, and that the natural development of this sort of dynamical force has its beginning and end, in reference to the whole scheme of Nature.

Our general conclusions with regard to cohesion are therefore as follows.—Oblong atoms are supposed to repel each other. When they become spherical, they begin to attract each other, and to cohere in virtue of the general principle of centripetal attraction; and this gravitating principle is more intense independently of chemical laws, as each atom becomes more oblate, in consequence of the same quantity of the attracting force being condensed in a smaller space. Hence the ultimate atoms in the heaviest substances must be supposed to be the most oblate or diminished in size.

But an opposite order of change in the intensity of the cohering force appears to be simultaneously prevalent in the chemical progression, in which the cohesion becomes *less* intense in proportion to the *complicated* character of the cohering molecules; and while it is easily interfered with in the higher stages of chemical combination, it seems to resist all mechanical or analytical efforts in the earliest stage.

Attraction, however, may exist, where there is no cohesion. We cannot account for any *quasi-contact* of atoms, which have previously repelled each other, unless we admit that they subsequently draw each other into union by the force of attraction; and this applies equally to the ultimate separable molecules of hydrogen, and to the inseparable constituents of the penultimate particle in other ponderable bodies. Neither can we explain the alternations of approximating and receding movements, as regards the orbits of the heavenly bodies,—when we do not avail ourselves of the aid of the hypothetical centrifugal energy, —unless we suppose the prevalence of the attractive as well as of the repulsive forces; but in our explanation of the astronomical phenomena of motion, we are obliged to have recourse to our ideas of *positive* and *negative* or of opposite electrical states, which are suggested by experiments in electricity.

It has already been shown, that although cohesion implies *fixation* and an absence of that reciprocally induced locomotion which is constantly maintained in the astronomical relations of distinct stars,—the contact between any cohering individual atoms, particles, corpuscules, or masses of different sorts of substance which constitute the same heavenly body,—may be only the cohesion between their *non-atomic* envelopes, or those segregated layers of the homogeneous ether, which, according to our hypothesis, surrounds all individual bodies, be they single atoms or planets; we do not assume that atomic substances can ever be in *absolute* cohesion. Moreover, we meet with no difficulty in supposing that such envelopes are amenable to many changes: they may be shallower or deeper, as they are more or less acted upon by electrical causes; and the expansion or contraction of bodies are thus easily explained; for the absolute contact of their respective envelopes need not be interfered with by the dilatation or contraction of the envelopes themselves, although the atomically composed particles may be brought nearer, or removed farther from each other, by the changes in question.

That any portion of a heavenly body once separated from it, will thenceforward hold orbitual relations of continuous motion to the mass from which it has been detached, is one of the postulates in La Place's cosmological hypothesis. This may be easily accounted for: but, we find reasons for doubting the existence of a centrifugal force, to which that celebrated mathematician attributed the separation between the Sun and the other bodies of his system. —We must search for some other cause of the absolute severance, and for a force capable of counteracting the centripetal cohesive energy, which would appear, at first sight, to preclude the possibility of any portion of a distinct, but connected, mass of atomic matter being absolutely separated from it, more especially as no *electrically repulsive* force of which we have experience, can overcome the general force of centripetal attraction.

Therefore, as we are not allowed to avail ourselves of a counteracting centrifugal energy, in consonance with our doctrine,—and we have no authority for assuming, that mutual repulsion is the cause of the dislocation, when oblate or spherical atoms are concerned,—the only sufficient physical cause for such an operation, which comes within the limits of our experience, must be some *antagonistic* influence of mutual attraction depending upon the gravitating relations between distinct heavenly bodies.

SECTION IX.

On anticentripetal or disjunctive attraction.

The secular contraction of the mass of every heavenly body must be one of the consequences of a gradual diminution in the sizes of its various atomic constituents; but the general influence of centripetal gravitation would nevertheless tend to the maintenance of its spherical form, unless the action of that force were interfered with by some other influence. The existence of such an antagonistic power is made manifest in the *tidal* action of the Moon and Sun upon the Ocean, and, according to analogy, upon the atmosphere of this planet; and if the ecliptic and the equator were the same, and the Moon had no declination, there would be a regular tendency of the waters to rise higher at the equator than in any other part of our globe, supposing its surface were entirely covered by the sea. Undoubtedly the equatorial circumference would never be circular in such a case, because there could not be a *simultaneous* rising of the water on all parts of the equator; the tidal waves of the atmosphere and sea would follow the vertical motion of the external heavenly bodies, which would give an oval outline to the equatorial surface; but still this must produce a general tendency of the fluid water and gaseous atmosphere to be more generally upon the equator than on any other part of the surface, and thus interfere with the sphericity, which depends upon the centripetal force of the whole terrestrial combination of atomic matter.

Now, supposing that the external attraction were derived from such a body as the ring of Saturn, instead of from the Moon or Sun, and that it acted equally on every portion of the gaseous atmosphere upon the equator of Saturn himself—it is evident that the particles of Saturn's atmosphere would be more affected by this external interference with the centripetal force immediately under the ring than on other parts of the surface, and that if we did not take the attractive influence of his satellites and of the Sun into the account, Saturn's atmosphere would have the outline of an oblate spheroid. In such a case the external reciprocity between the particles of his surface, and the mass of the ring, would hold an antagonistic relation to his centripetal force of general cohesion, interfering with it, to a greater extent upon his equator, and to a less extent at his poles, than elsewhere upon his surface. The principle of the antagonism between these two forces would be perfectly developed under such conditions.[i]

Both these sorts of attraction differing so completely from each other, would, however, be distinct from that reciprocity between the whole body of Saturn and the entire ring, which contributes to their relative locomotion, or to the astronomical activity of any two distinct heavenly bodies which describe elliptical orbits in consequence of their inductive reciprocity of alternating processes of attraction and repulsion.

We can understand that the continuously increasing tendency of the particles near the equator of Saturn, to resist the centripetal force of cohesion, and to rise under the influence of the ring, would gradually operate upon his whole surface, and at last bring all the gaseous matter of his atmosphere,—and, probably, all the fluid substance which covered his surface,—to the equator. The general influence of the centripetal attraction of his mass would therefore be diminishing, as such particles became more distant from his centre, and at last the external attraction might preponderate, so as to cause a fracture between the outer equatorial portion of his matter and the bulk of his body. The result of this operation might be the distinct existence of a *second* ring between the body of Saturn and the *original* outer ring which was the cause of his centripetal force of cohesion being interfered with, and finally nullified, as regards the substance of the second ring. Instead of two, there would be three distinct heavenly bodies.[k]

i The peculiar form of the surface of Saturn, first noticed by Sir W. Herschell, may be attributed to the attraction of his rings, acting from their surfaces *obliquely* upon those portions of the planet, which would be exposed to such an influence. This would account for the irregularity of Saturn's peculiar outline, which is not that of a spheroid whose major axis is on his equator, as happens with regard to the Sun, and the other planets: and it would also support the doctrine which substitutes an external anti-centripetal attractive force for the centrifugal tendency, as the cause of their oblate forms.

k The ring of Saturn is evidently composed of more than one layer;

Applying this notion more generally, and granting that each gaseous or fluid ring may itself have a tendency to be consolidated upon one or more centres in its own mass, as La Place has supposed in his theory,—we may assume that every planet in the solar system was derived from the atmosphere of the Sun in accordance with the above principles, and in consequence of the centripetal force of the Sun himself being interfered with by the external influence of some other sun or fixed star, which acted upon his particles.

If the planets were thus formed in succession, (at first appearing as rings of matter detached from the Sun's general body, and eventually conglomerating into spheres), the same hypothesis may be applied to their centripetal forces being still interfered with by the external attraction of the Sun; the general consequence of this interference would be the distinct existence of such separate disconnected heavenly bodies, as the ring of Saturn, and the satellites of any planet; and they would become new causes of interference with the centripetal influence of the parent body from which they were detached. The existing ring of Saturn may have been separated from his surface by the influence of his many satellites, which were all originally rings themselves, and they (or at least the outer ones) may have been detached by the influence of the Sun.

Thus far we meet with little difficulty in accounting for the disjunction of parts of the same mass, and in arriving at the conclusion, that one or many solar systems may have originally been the component parts of a single heavenly body. But another cycle of the change remains to be considered; the future, as well as the past and present, conditions of our planetary system ought to be the subject of meditation. The dissolution of the Sun and all its

but the existence of a single layer or single ring is assumed in the argument, in order to simplify the proposition.

planets seems probable ; the secular contraction and final evanescence of every atomic constituent of the whole solar system, and of every visible star which now affects our vision, must be the inevitable consequence of the slow but sure process of change which appears to be unceasingly occurring in Space, if there be any truth in the elementary doctrines submitted to the reader in the present treatise, about the ultimate evanescence of every existing atom.

The whole course of argument adopted by La Place supposes, that the substance of the entire solar system is gradually becoming more condensed; he has not entered upon the physical or chemical questions which are involved in this assumption, but it is inseparable from his scheme, which accounts for the present condition of the solar and planetary bodies.

Now, if it be a fundamental law that every distinct atom is undergoing a change which will embody it in a succession of molecules, whose volumes diminish while their atomical weights remain unaltered, and if this notion be applied generally to the substance of the Sun and of every heavenly body in his system,—it is evident that the era will arrive, when all these bodies will only consist of particles having the characteristics of some of the heaviest known substances, or of substances far more condensed than any which we have observed on this planet. In Jupiter, Saturn, or Uranus, these sorts of heavy substances may exist at present, and they may also constitute a portion of the Sun himself. We cannot affirm, however, that their existence necessarily suggests the absence of vapours or liquids, because some of the heaviest substances, might, like mercury,[1] be in a state of gas or of fluidity, if

[1] The existence of so heavy a substance as mercury in a state of fluidity under the mean ordinary temperature of our planet, is an important fact, because it shows that the hypothetical *general* rule has an exception with respect to the conditions of a substance always being in relation to its weight. Mercury is the only heavy metallic

the present atmospheric pressure were greatly diminished. There are also reasons for supposing, that, however contracted its ultimate atoms may have become, the extreme surface of our planet will be always in a gaseous state.

Let us however suppose the possibility of all the matter of a heavenly body being in a solid condition, and meditate upon the results of an antagonism between the earth's centripetal attraction, and the *anti-centripetal* power of the sun and moon, in such a case.

It is more easy to account for the disjunction imagined

substance which is fluid unless a great heat be applied: still its existence implies, that the system of laws regulating the gaseous, fluid, and solid states of matter, is independent of the absolute size of its ultimate atoms, or of its gravity.

In a subsequent portion of the present treatise (Essay iv. Sect. 5), the reader will find a digression upon the *normal* elasticity of gaseous bodies, in relation to the surface of a star or planet, where the envelopes of its molecules (whatever may be their specific weight) can only be compressed by the surrounding ethereal medium which pervades space. It is assumed that in such a position the envelope of the atom, particle, or corpuscule, would be at the extreme point of its expansibility, and that it must then be necessarily in a gaseous state.

All the phenomena of congelation and liquefaction suggest that there is a fixed point in the scale of expansibility, where *gaseous* elasticity becomes *latent*, because the expansibility of water in the condition of steam is nullified to a great extent when it is condensed as a fluid; and as gases may be made fluids or solids under pressure, we find satisfactory reasons for the extreme layer of atomic matter on the surface of every heavenly body being always in a gaseous state, even if the specific gravity of its ultimate atoms were a hundred times that of mercury.

Hence, it is probable that whenever any astronomical separation of the substance of a heavenly body takes place, the matter disjoined from the parent mass is in a gaseous condition. Should this be correct, the subsequent remarks in the text of the present section—so far as the *external surface* of any heavenly body is concerned—must be regarded as an attempt to demonstrate what *might* occur, if its solid substance could be detached *externally*. But as regards the *geological* consequences, which would be the result of the secular atomic contraction of its constituent molecules, when the locomotive force thus generated *from within* upon its surface, is antagonistic to the *external attraction* of another heavenly body—the argument is not hostile to the supposition, that the substance of the satellites or rings of a planet may have been disjoined in a gaseous state, and solidified afterwards; neither does it militate against the possibility, that the *internal* nucleus of a planet may have been entirely disjoined from its surface shell, while they were both in a solid state.

by La Place, when the separated portion is a vapour or a liquid, than when it is solid. The greater degree of cohesion between the portions of a solid surface than between liquids or vapours, must occasion a greater resistance to any external attraction, and a less tendency to separate from the mass. Still, that gradual contraction of the mass of a solid sphere which would be produced by the secular diminution of all its atomic constituents, must act mechanically upon its surface; and every portion of that surface must be gradually converging to the centre of gravity, and gradually undergoing a change of place, unless it be retained in its locality by the rigidity of the whole surface, or by some external attraction.

Thus in relation to a solid, we cannot dispense with a *movement of the surface* under such conditions; but we may assume that its rigidity interferes with the regularity of the movement, and promotes internal dislocations *under the surface*, at some point between it and the centre of gravity in the body; any such rent having once commenced, might be extended from one pole to the other, or be continued as a great circle all round the planet in any direction. When however we suppose that the *external* force of the sun and moon acting within the tropics upon or near the equator, causes an expansive locomotion of the solid surface, and still further interferes with the general centripetal tendency to converge *inwards* to the centre of the earth,—it is evident that this constancy of the external influence would give a continuous direction to the rents or *lateral chasms* of dislocation, and occasion their commencement in the equatorial regions. The centripetal gravitation of the planet would be less interfered with by such an external antagonistic force at the poles than elsewhere, but those portions of the surface which were within the tropics, would be less easily moved towards the centre, than any others.

Less mechanical force would be requisite to bring about the entire separation of a shell of the earth from the mass (the rent having once commenced, either latitudinally or longitudinally, under the equator) than would be necessary to force the surface to accommodate itself to the general contraction of the sphere. We may however conclude, that if any one rent or crevice were thus occasioned, many such would take place in every direction, and that they would cross each other, and interfere with the general cohesion superficially as well as laterally. Should the disjunction be complete, the result might be the existence of *a solid sphere wholly surrounded by a distinct envelope or shell* of solid terrestrial matter. In treating of terrestrial magnetism, we shall presently shew that our planets being in such a condition will harmonize with some otherwise unaccountable phenomena connected with the variation of the compass,—supposing the spherical nucleus and the external shell to be as completely separated from each other, as Saturn is from his ring.

Many geological phenomena may also be explained by the supposition that there are subterranean rents or chasms in a more or less advanced state, under certain portions of the earth's surface. Subsidences and earthquakes, accompanied by violent developments of an electrical force propagated along the inner surfaces of these immense caverns, may be due to the existence of hollows, into which superincumbent regions of the surface sink ; and the external appearances resulting from catastrophes of this description would be the sudden elevation of mountain chains, as M. Elie de Beaumont has shown in his theory, where he endeavours to account for such violent changes having taken place upon the surface of our planet.

It is also an argument in favour of this hypothesis, that the entire separation of the crust of a planet and of its interior, may have occasioned a considerable intervening space, like that between Saturn and his rings. Such a condition would account for a remarkable and seemingly inconsistent phenomenon with regard to gravitation; for astronomers concur in attributing an extraordinary want of weight, or a most disproportionate specific gravity to Saturn, when there are reasons for supposing that his substance is generally more condensed than that of the earth, if there be any truth in La Place's theory, or in the general chemical hypothesis presented to the reader in the present treatise.

Should the visible surface of Saturn be a mere shell surrounding a sphere, with a considerable interval between them, or surrounding a series of shells one within the other, —the solid body being the inmost—there will be no difficulty in explaining the cause of this surprising absence of gravity. Without some such mode of accounting for it, we must suppose that the individual atoms which compose the bulk of Saturn have a less weight than those of our own planet, which would be in opposition to the general doctrine, that every *ultimate* atom in our system has the same specific gravity (due regard being had to distance), whatever may be its condition of contraction. The whole doctrine of definite proportions in chemistry is founded upon that assumption. On the other hand it is hostile to the theory of La Place, and indeed of any other philosopher who has theorised upon the subject in modern days, —that the atomic constituents of so distant a planet as Saturn should individually occupy so large a space as must be the case if the whole orb were full of atomic matter.

Admitting, however, that this general separation of an entire spherical shell of any heavenly body from its general mass must occur, we have still to account for the breaking up of the whole body. But having once satisfied ourselves of the probability of such an *anticentripetal* result, we shall find no difficulty in supposing that the shell itself undergoes the same disjunctive process, and that it may be fractured in all directions, to such an extent that its surface may be at last in the condition of mere scales which yield to the external attraction, instead of adhering to the surface of the heavenly body.

In the case of Saturn, for instance, it is by no means improbable that the centripetal attraction which binds together the atomic matter composing the outer shell of that planet, may be so overcome by the external attraction of its ring, that its substance is liable to *scaling off* in consequence of the *mechanical* action resulting from the gradual diminution of its constituent atoms, which interferes with the regularity of its cohesive attraction. Should this phenomenon occur, we can understand that the attraction of the ring may overpower the direct centripetal attraction of the shell itself, and that if the inductive attraction of the inner nucleus be less energetic than that of the ring, the tendency of the liberated substance would be to separate from the outer shell. It is evident that according to such an hypothesis, the external attraction must be more powerful than the combined influence of the cohesive energy and of the attraction of the inner nucleus, which last would be of the same species of gravitating force as that of the ring,—both distinct bodies, the internal nucleus and the external ring being altogether disjoined from the shell (the real seat of the *conductive* cohesion in question), and only acting *inductively* upon its substance.

We may thus speculate upon the gradual dislocation of all the substance of the shell, and upon its becoming a ring of distinct heavenly bodies, which from their minuteness and mutual proximity might appear to us as a connected ring. It is not necessary that when the offsets from any heavenly body were first separated from it, they should have been composed of such greatly diminished atoms; for their *subsequent* contraction would give them a greater attractive energy in regard to the space which they might occupy, even supposing they had been originally separated in a gaseous or fluid form.

With respect to our own planet, surrounded as it is by a gaseous atmosphere, and more than one-half covered by matter in a state of fluidity, we are not warranted in assuming that any substance has yet been separated from it in a solid form; but the existence of the Moon would suggest that gaseous or fluid substances have been consolidated and condensed since its separation. When, therefore, we consider this modification of La Place's hypothesis as one complete scheme, we have grounds for believing in the possibility of a gaseous or fluid substance which has been disjoined by an external attraction, being the cause of a subsequent interference with the bulk of the parent body, and at last withdrawing solid particles from it.

The system of Saturn may be in this condition: his outer satellites may have been separated from the parent body in a fluid or gaseous state by the external attraction of the Sun: the process of condensation may have operated more rapidly, for reasons which will be adverted to hereafter, upon the detached zones of gas or fluid, than upon the surface of Saturn himself: they may have interfered with his cohesive gravitation and detached his solid particles from the outer shell of the planet, which may constitute rings or belts of innumerable distinct bodies, appearing to us at this distance as if they were homogeneous flat masses in the plane of his satellites; and they may again act upon the present surface of the planet with a still greater inductive energy than that of his satellites.

The periodical appearance of the shooting stars on certain nights of the year, may be explained in accordance with his hypothesis: they may have been detached from the earth as unconnected bodies since the separation of the substance now constituting the Moon, and may revolve round our planet in elliptical orbits, *under such conditions that we only see them when near their perigee.* Each of them may be a satellite of the Earth; and if they were as numerous as the emanations from Saturn, they might have had the appearance of a connected ring, when seen from other planets.

But when the whole notion is considered in relation to the future and final breaking up of the entire solar system, we can imagine the possibility of the outer shell or surface of each body dividing itself into very minute bodies, and constituting a series of rings, each composed of innumerable satellites, even when that outer surface is devoid of gaseous or fluid matter. This process may go on, until the entire shell is disintegrated; and the same operation would act still more energetically on the surface of the next shell or nucleus, because all the matter originally in the outer shell would counteract the centripetal or cohesive gravitation of that which is now exposed. The farther the disintegration advances, the more antagonistic would be the inductive action of the anti-centripetal force. The final result might be the gradual disappearance of each planet and satellite in succession, the oldest or outermost being broken up first, and the Sun himself eventually becoming, like them, rings or zones of minute masses of atomic particles, under the influence of other heavenly bodies.

It follows as the ultimate consequence of such a general antagonism of the *centripetal* and *anticentripetal* forces of attraction, that every heavenly body or connected system of bodies contains within itself the elementary principles of its own development and dissolution,—and that even separate solar systems, each of which has had its distinct beginning in Time, may act upon each other. Our Sun, when composed of a gaseous substance, and extending beyond the limits of Uranus (as La Place has supposed it once did), may have always been in reciprocity with another Sun, which was either in a similar condition, or in one very different as regards the state of its own atomic constituents. But when considered in its first conceivable atomic condition, the solar system must have been *one* connected mass held together by the conductive force of centripetal cohesion. The last astronomical state of its atomic matter (if there be any verisimilitude in our doctrine) would be that of rings or zones composed of an infinite multitude of distinct minute heavenly bodies, occupying the localities of those planets and satellites into which it has been and will be successively divided.

SECTION X.

On astronomical attraction and repulsion, and their general prevalence in the manifestation both of the orbitual *and the* rotatory *movements of heavenly bodies.*

The absence of any thing like cohesion in the phenomena of astronomy, and the apparently perpetual motion of the heavenly bodies, are facts which are constantly under our observation. The inferences of mathematical astronomers about the opposite tendencies of centripetal and centrifugal forces,—and the assumptions that comets may fall into the Sun, that the substances of cometary tails fly off from their nuclei, and that there is any such process in Nature as centrifugal radiation,—are not in harmony with any of the known laws of gravitation.

We have no reason deduced from direct observation or from analogy, for supposing that any mass of atomic matter can be dispersed, unless we imagine the intervention of some external attraction, or of some force which resembles electrical inductive repulsion.

The theory of La Place, which is based upon a rotation of the originally combined mass of the substance now composing the Sun and all the other bodies of his system, and upon the supposition that a *centrifugal* force is sufficient to account for the disjunction of zones or rings which eventually become planets,—is incomplete in many respects, but more particularly because it assumes that the original rotation is the cause of the revolution of all the planets and of all their satellites in the same direction as that of the Sun's rotation. *The satellites of Uranus have an orbitual movement in a contrary direction*; and this exception to the general rule is sufficient to overthrow the basis of his hypothesis.

The great astronomical problem, which he has disposed of as a geometrician, must be considered as one in which not only the mathematical laws of celestial dynamics are engaged, but as a question involving the known laws of *electrically-produced locomotion*, and certain arithmetical influences which hold an analogy to those of definite chemical proportions. The laws known by the names of their illustrious discoverers, Kepler and Bode, are no less influential in regard to the problem than those of the dynamical mathematician. We should also probe the whole question without admitting that any celestial body has an inherent or aboriginal tendency to move in space: the causes of the original impetus, of the direction of the movement, and of its modification, ought to be the objects of our inquiry. Nothing should be taken as granted, unless it be an abstract law; and the postulate of the *vis inertiæ* or of a centrifugal force (which can at best be only *data* having the characters of axiomatic postulates) are wholly inadmissible, because they are mere hypothetical assumptions inferred, instead of being proved, to be of the same nature as mathematical postulates.

But the theory of La Place has the great advantage of suggesting a reasonable cause for the origin of the distinct planetary bodies in the solar system, and for their existence under their present conditions. In this respect the great French astronomer made an important step in advance of his predecessors, who considered the existence of each heavenly body as a fact, and spoke of the original momentum as of some vague impetus given to each such body "in the beginning," in the same way as chemists have treated the ultimate atom of any given substance, without investigating possible previous conditions.

In the preceding chapter an attempt has been made to modify this hypothesis of La Place, and to substitute the combination of two forces—that of the condensation of any mass of atoms in consequence of the secular diminution of the bulk of each of its ultimate atomic constituents—and that of an inductive *external* attraction which would interfere with the conductive or centripetal attraction of each atom in the heavenly body. The result is supposed to be the same as that hypothecated by La Place.

With respect to the *orbitual* movements of the heavenly bodies, if we adhere to the doctrine that it is occasioned by a reciprocity between two such bodies,—that the orbit is elliptical,—and that it may be disturbed by interfering influences of a third, or of many other such bodies—while on the other hand we discard the notion that the centripetal and centrifugal forces of geometricians can account for these motions,—we discover a sufficient cause in the great electrical law which determines that bodies similarly electrified should be mutually repulsive, while those which are in dissimilar electric states, should attract each other. If we assume, for instance, that the planets and comets in the solar system are constantly undergoing inductive changes of their electrical conditions in proportion to their proximity to the Sun (the preponderating central body of the system) we can understand that he would sometimes attract and sometimes repel them.

It may also be shown, that the *rotation* of the *surface-shell* of each heavenly body can be similarly accounted for, supposing the shell and nucleus to be distinct and separate from each other, instead of being conductively connected: but the relations between concentric spheroidical bodies affecting each other under these conditions, would be specifically different from those which prevail when they are in the respective positions of the Sun and one of his planets, or in those of the Earth and the Moon.

According to our hypothesis, the electrical condition of a planet or a comet gradually changes as it approaches or recedes from the Sun. During its approach, it becomes electrically like the Sun; and when the similarity of the electrical states of the two approximating bodies is complete, they mutually repel, instead of attracting, each other. This consequence would produce another, namely, the increasing difference of their electrical states; and when such a difference has attained its climax, the planet or comet may be supposed to be at its aphelion, and to return to the Sun. Thus the difference in the electrical conditions of the two reciprocating bodies may be adequate to the promotion of the locomotion; and the locomotion may occasion the difference of their electrical states; although this mode of argument is not allowed in logic, since it seems to be what is called reasoning in a circle, it appears admissible in the automatic system of Nature, where a sort of perpetual motion may be maintained by the action and reaction of a physical force; and where two sets of phenomena may mutually hold the relation of reacting causes and effects.

But this solar relation cannot be the specific cause of the magnetic or inductive reciprocity between the shell and nucleus,—or between the many shells of the same distinct heavenly body, whose outer shell is the external limit of the category. As it moves towards, or recedes from, the Sun, all its distinctly separated portions must be affected by the common orbitual movement, and they must all be *generally* electrically positive or negative *as regards the Sun.* The only *locomotive* relations which we can imagine to be developed by their reciprocities in such a case, would be one holding an analogy to the revolution of a satellite round a primary planet. It may be demonstrated, that Saturn's ring rotates in accordance with the same subordinate system of relations to Saturn himself, as those of his satellites; and it will not be difficult to show, that a hollow shell, completely surrounding a solid sphere, or another shell,—from which, however, it is as distinctly separated in space, as the ring is from the surface of Saturn himself,—would revolve round the internal nucleus, as if it were a flat ring or a satellite. Hence it may be surmised, that one of the reciprocating effects of the inductive influence of the nucleus, would be the rotatory movement of the shell; but that when a heavenly body is not thus divided, it would have no rotation.

The rotation of some heavenly bodies upon their axes, during their orbitual locomotion, is a phenomenon which has never been satisfactorily explained. General laws of gravitation have been resorted to as causes of this species of movement, which do not appear to be universally prevalent. The diurnal rotation of Mercury occupies more time than that of the Earth; Venus nearly forty minutes less; Mars nearly forty minutes more; while that of Jupiter is performed within ten hours, and that of Saturn within eleven. This irregularity offers, at first sight, a striking contrast to the harmonious generalisation of Kepler's law in regard to the *orbitual* locomotion of the planets, which determines that the squares of their periodic *times* of revolution are to each other, as the *cubes* of their mean *distances* from the Sun.

Again, with respect to the satellites,[m]—there is really no rotation of the Moon in relation to the principal and reciprocating governor of its orbit, namely, the Earth,—although modern astronomers affirm, that she makes one complete rotation during her revolution round it: but this apparent rotation has reference only to the Sun. The same remark applies to the other satellites: so far as we can ascertain from observation, they always present the same face to their respective planets, although they may seem to rotate to us, who are looking at them from points beyond their special and subordinate systems.

It is evident from these facts, that the principle of any heavenly body's rotation on its axis, does not depend upon the direct relations between the Sun and his planets; and our meditation upon the subject will suggest, that the cause is connected with the special constitution of each separate body. The absence of any real rotation in the Moon, not only suggests that the Sun can exercise no influence upon her in this respect, but that the Earth's rotation does not communicate a similar movement on its axis to its own satellite. The general conclusion moreover, is, that were it not for some cause peculiar to each rotating heavenly body, it would perform its revolutions without any rotation; hence it is an important question in astronomy to ascertain, why rotation is made manifest at all.

[m] The ancient astronomers maintained that the Moon does not rotate. When mathematical science was further advanced, a beautifully harmonious series of calculations was adduced to prove that this opinion was false; but although the mathematical theory accounting for the balance of the attracting influences of the Sun and the Earth upon the Moon in this instance is incontrovertible, it is precisely of the same order of calculations as those which prove that Saturn's rings do not fall in upon the planet in consequence of compensating or antagonistic forces. The existence of the harmony in question does not prove the original possibility in either case. Many physical errors have been, in like manner, supported in opposition to facts, by correct mathematical calculations.

Our data for the solution of this problem are as follows.

1. The non-existence of rotation in the Moon, in relation to the Earth.

2. The analogy between the *rotation* of the ring of Saturn and the *orbitual* revolutions of his satellites, which suggests that the rotation of every heavenly body is the *analogue* of the *elliptical orbitual* movement of secondary heavenly bodies, revolving round it in accordance with the same general system of laws, as those which occasion the orbit of the planet itself in relation to the centre of the solar system.

3. The fact of the rotation of the Sun upon his own axis, although he is the centre of his system.

4. The hypothesis, that every apparently single heavenly body may consist of two or more distinct masses of matter one within the other, the intervals between them being devoid of any aggregated or cohering atoms, which would *conduct* the electrical or magnetic influence,—and that the same laws of *inductive* reciprocity would prevail subordinately between them, as prevail specifically between Saturn, his ring, and his satellites,—or generally between Saturn and the Sun in the solar system. We have already attained this hypothesis by meditating upon the results of the *anticentripetal* attractive influence of the mass of one distinct heavenly body acting *inductively* upon the molecules of another.

5. The phenomena of the variation of the compass, with respect to contemporaneous geographical observations upon different portions of the surface of this globe, as well as to recorded changes in the position of the magnetic poles at any given point upon its surface.

In reference to such data, taking them in the above order, it has been already remarked that what is called the Moon's single rotation during the period of its revolution round the Earth, is really no *absolute* rotation. The same side of this satellite is always turned towards its principal; and the slight oscillations which have been satisfactorily accounted for by experienced mathematicians, have nothing to do with the movement of rotation. Any ball projecting on the felloe of a wheel, *when viewed from the outside*, would appear to make one such rotation during the wheel's revolution on its axis; but when that ball is seen *from the centre of the wheel*, it will always present the same side of its surface to the observer. The rule or principle of rotation is evidently the relation which such a ball revolving round the nave, would hold to the axle of the wheel itself. When we consider the whole surface of the Moon as if it were this ball projecting from the felloe of the wheel,—the Earth being the axis line of the wheel, and the Sun being the point of observation beyond the felloe,—the rays of the Sun must necessarily fall upon each part of the projecting ball in succession, which would correspond with the luminous appearance presented during one orbitual revolution of the Moon: this, however, instead of proving that the ball revolved on its own axis, while it was carried round the nave of the wheel, would demonstrate the contrary proposition.

The fact, that the Moon does not rotate, in relation to the subordinate terrestrial system, leads to the inference that the *diurnal* rotation of the Earth has no effect in producing a corresponding motion in the Moon,—and by analogy, that the rotation of the Sun has nothing to do with that of his planets. The only leading locomotive relations in either case appear to be those which determine the periodical revolutions either of a rotating or non-rotating body *round its principal* in an elliptical orbit: and supposing this to be the relation between Saturn and his rings, which promotes their rotation, we may be enabled to satisfy ourselves that the apparent rotation of any body upon its axis, is but *a modification of an orbitual movement* occasioned by the same sort of reciprocity as that which gives all heavenly bodies their orbitual revolutions. It may also suggest, that where a heavenly body has no rotatory movement on its axis, it is that which it appears to be,—namely, a solid mass; but that where it has a rotatory as well as an orbitual movement, it consists of two or more detached and distinct bodies (a ring for instance hooping in a sphere, or a detached shell completely surrounding it), which occasions a rotation of the ring or shell upon the same principle, as that which prevails in the orbitual movement of planets with regard to the Sun, or of satellites with respect to the primary planets.

If this can be established, we may affirm that the Moon is solid,—but that the Earth consists at least of two wholly distinct and noncohering bodies, an outside spheroidical shell and an internal solid sphere or spheroid.

2. The rings of Saturn have a rotating motion in the same direction as that of Saturn himself, and in very nearly the same periodical time as would be that of the revolution of a satellite, supposing it occupied the middle of the breadth of the rings. This period has been determined by the observation of some of its portions which are rather more bright than the others, to be longer than the time occupied by one rotation of Saturn himself. Our inference is, that the same *general* law as to "times and distances" prevails in the rotation of Saturn, of his rings, and of his satellites,—and consequently that there is an analogy between the apparent rotations of Saturn and his rings, and the orbitual revolutions of his satellites.

According to the analogy, the shell ought to rotate with greater rapidity than the rings,[n] and the rings would per-

[n] Our calculations, however, will show that the rotation of any planet occupies more time than a satellite would do, if it were at the same

form their revolutions more speedily than any of the satellites which are beyond. We are also justified in the assumption that the irregularities (which are called oscillations in the rotations of the rings, under the supposition that they move circularly) are mainly due to the elliptical character of their motion, although it may be interfered with to a certain extent by external attraction, because there would be perturbations occasioned by the inductive influences of the Sun, of the satellites, and of the shell of Saturn himself, which has a movement of its own: but most of the apparent irregularities would be disposed of, if it were admitted that *the rings move elliptically instead of circularly.*

The shell itself, according to this doctrine, would also appear to oscillate, although to a less extent, because the eccentricity of the ellipse which it would describe in rotating round the internal nucleus, must be very small. Still if the doctrine be admitted, it becomes a necessary consequence that the outer shell of every rotating heavenly body performs an *elliptical* revolution having the character of a planet's orbit in relation to the Sun, or that of a satellite in relation to its primary planet, instead of rotating circularly as if it were a solid body. In such a case, a modification of Kepler's law about the times and distances might be expected to prevail, and the apparent rotation of the whole body may only be the orbitual revolution of its external shell, the *internal nucleus* acting as the *primary* body of its own special subordinate system.

3. The rotation of the Sun upon his axis cannot be supposed to be the consequence of his planets revolving round him. It seems more probable that if his surface be that of a detached shell, the same general law should pre-

distance from the centre of the planet as that of the planet's equator from its polar axis. This apparent contradiction of our assumption is explicable, when we remember that the surface of a planet is a complete spheroid instead of a point, as will be shewn in relation to the rotation of the Sun upon his axis.

vail both with regard to the *orbitual* revolutions of his planets and to the *rotatory* movement of his own surface.

Now, it will be found that if we apply the *principle* of Kepler's third law to the rapidity of his rotation (considering a point on the Sun's equator as the analogue of a planet,—the *time* or duration of its complete circuit, as that of the revolution of any of his planets,—and the length of his equatorial radius, as the distance of any given planet from the Sun's centre),—we shall discover the same *general* harmony as that which Kepler found in his comparison between the *squares* of the *times* and the *cubes* of the *distances* of any two planets.

It will appear, that the square of the orbitual revolution of any planet will be to the *square of the period of the Sun's rotation on its axis* as the cube of that planet's mean distance from the Sun, is to *the cube of the Sun's equatorial radius multiplied by* 50,000. There are eleven known planets which revolve round the Sun, and in each case the difference as to the result is shown in a small fraction.[o] The general conclusion is, that the sum found,

[o] Applying the principle of Kepler's third law to Mercury and Uranus, the planets nearest to and farthest from the Sun, we find the following satisfactory results: our *data*, it must be remembered, are not precisely ascertained.

Orbitual period of Planet in days.	Period of Sun's rotation in days.	Mean distance of Planets from the Sun in miles.		
$87,96^2$	: $25,50^2$: :	$37,000,000^3$:	4257112152398429895270	Mercury
$30688,71^2$	: $25,50^2$: :	$1832,000,000^3$:	4245213165038364539424	Uranus
			0011898987360065355846	Difference
			4251162658718397217347	Mean
Cube of Sun's equatorial semidiameter multiplied by 50,000. Semidiameter taken at 440,000 miles.			4259200000000000000000	$= 440,000^3 \times 50,000$
Difference between the mean of the results given by the above equations, and the sum obtained by multiplying the *cube* of the distance between the Sun's centre and a point on his equator by 50,000; 0002 in the case of Mercury; 0014 in the case of Uranus.			000.8037341281632782653	

instead of being the cube of the distance between any point upon the Sun's equator and his centre, is fifty thousand times that quantity; therefore the movement of such a point is less rapid than would have been the case, had the point been the centre of a detached planet.

As the sum thus indicating the rotation of the Sun is a general quantity, whatever may be the planet with the duration of whose revolution it may be compared, the result is quite as wonderful as that discovered by Kepler, because it is in harmony with the same general principle.

When we meditate, however, upon the great difference between the revolution of a spheroidical shell around a within-contained central body from which it is detached, and that of so comparatively small a revolving body as any of the planets beyond the shell, we can understand that the same moving force must act very differently in the two cases. The assumed point upon the Sun's equator must be moved with the mean rapidity of the whole shell: had it been an isolated point close to the poles of the shell, its velocity would have been incalculably small, and if it had been immediately over the poles, the rapidity of change of place would have been absolutely null. This consideration alone is not sufficient to account for the difference; but it leads us to the calculation of the diffusion of the force over the whole surface of the shell, the general or mean energy of which is shown by the rapidity of any point at the greatest distance from the axis of rotation; and it demonstrates, that many more times the quantity of force would be necessary to give the same ratio of movement to the entire shell, than would be necessary in the case of a planet if it were at the distance of the Sun's equatorial radius from his centre.

When this idea is applied to the rotation of *other* heavenly bodies, in accordance with our hypothetical method of accounting for that sort of astronomical motion, we may probably discover a rule for calculating the specific gravity of the outer shell of each body in relation to its within-contained nucleus, and also for ascertaining the depth of the shell itself,—supposing we knew the general difference of rapidity of a merely superficial shell, as compared with that of a flat ring like those of Saturn,—or of a satellite.

This general difference would represent the collective force (without taking into account the density of the surface portion) acting upon a complete shell with an energy increasing from zero, in relation to the distance from its poles to its equator,—supposing the force to be at its maximum at the equator and to be absolutely null at the poles. We shall find, however, that in three systems of satellites,—namely, those of the Earth, Jupiter, and Saturn, in which we can compare the rotations of the subordinate central bodies with the orbitual revolutions of their satellites—the difference, as regards each system, is a variable quantity. Our inference is, that if the hypothesis be correct, and the same general laws of motion prevail with respect to the rotation of the outer shell of a heavenly body and the revolution of its satellites,—there must be a difference between the relative conditions of the shells and of the within-contained but detached central portions of the Sun, the Earth, Jupiter, and Saturn. These differences, however, are regulated by a progressive law of numerical proportion, which is as harmonious as that discovered by Bode; and it seems to be of the same order.

When we apply this rule to the relation between the periods of the Earth's rotation on its axis and of the Moon's revolution round the earth,—we find that instead of the result being equal to 50,000 times the cube of the Earth's radius, it is not quite 290 times that cube. Again as regards the rotation of Jupiter upon his axis and the revolution of his satellites, the excess in favour of the satellites would be nearly about 12. But as regards the relations between the period of Saturn's rotation and the revolution of his third satellite, the excess would be little more than 4. If we base our calculation upon the square of the time and the cube of the distance of his seventh satellite, the excess would be greater; but that satellite is not in the plane of the ring.

We therefore find as a general rule, that the excess given by the equation diminishes, in relation to the distance of the rotating planet from the centre of the solar system,—in other words, that the rapidity of the rotation of a principal is greater, when compared with the revolution of the secondaries, in proportion to its distance from the Sun, when we calculate according to the rule laid down by Kepler.

It is evident from these calculations,

1. That there is a direct relation between the *rotation* of a heavenly body, which is the principal of any system, and the *orbitual* revolutions of its subordinates.

2. That although this general rule is modified by some special law, which determines that the rotation of the *principal* should depend upon its position in the solar system,—all its subordinates or satellites revolve round it, not according to a ratio common to the whole system, but to that which is peculiar to itself: yet the ratio special to every planet, holds a relation to the distance of that body from the Sun.

3. That the proportional rapidity of the rotation of a planet (when compared with the revolutions of its satellites) increases as it is more distant from the centre of the solar system,—and that if we could measure the rotation of Mercury, Venus, and Mars (which have no satellites), by the same test, we should probably find, that the ratio of their respective rotations has nothing to do with their

apparent diameters, or with the influence of the Sun, or of his rotation upon them.

4. That, supposing the rotating portion of a planet to be a shell distinct from an internal nucleus, and less dense in proportion to its distance from the Sun, while the interval between it and the nucleus has *gradually* become greater,—we attain a conclusion which is completely in accordance with the hypothesis of La Place about the present condition of the solar system,—with that advanced in the present treatise, about the gradual increase of the interval between the shell and nucleus of each planet, in proportion to the presumed duration of the period of its individual existence as a distinct heavenly body—and with the observations from which it has been inferred, that the specific gravity of Saturn holds no proportion to its bulk, unless we suppose it to be a solid consisting of matter which is not heavier than cork.

It also appears from these inferences, that the surface of the Sun is acted upon less energetically by its internal nucleus, than is the case with regard to the analogous action going on between the shell and the inner body of any planet in his system,— and consequently, that the specific gravity of Saturn's nucleus, does not hold the same proportion to that of his outer shell, as that of the terrestrial nucleus to the superficial portion of this Earth. But on the other hand, the same reasons which lead to the supposition that the visible portion of Saturn is detached from the inner portion of that planet, are equally applicable to the Sun. According to such conditions, it is in harmony with the known laws of astronomical dynamics that the apparent *rotation* of a heavenly body is an *orbitual revolution* promoted by a reciprocity between the inner and outer portions of the Sun or planet,—and that the movement is elliptical instead of being circular, although the eccentricity of the ellipse thus described might be scarcely appreciable by observation.

The disturbing forces so beautifully elucidated by mathematicians, may have greater perceptible effects than those occasioned by the elliptical motion of the surfaces of the rotating heavenly bodies. All the planets are undoubtedly disturbed by the interfering attraction of the Sun,—of other planets,—and of their own satellites; and the ring of Saturn may have a perceptible effect upon the rotation of the surface of that planet: but the Sun is so enormously larger than the planets, and the eccentricities of the ellipses of all the planets are so small, that this great central body of our system is peculiarly appropriate to any general observation in reference to the problem of the rotation of the heavenly bodies. The same consideration militates against the probability, that their rotation could have any measurable sympathetic effect upon him; and even if they were larger than they are, all analogical reasoning is against the supposition that the Sun's rotation depends upon the action of *external* causes,—since the rotation of our own planet, which is so much larger than the Moon, has no evident effect upon our satellite, who moves without rotation in her orbit round the Earth, as if she were a projecting point in a continuous ring, or in a spherical shell.

4. The detailed arguments advanced in preceding pages preclude the necessity of reverting to the astronomical hypothesis,—that all spherical or spheroidical *rotating* bodies may consist of two or more distinct parts, which are not connected by the attraction of cohesion, or by the general and exclusive centripetal gravitation which determines the specific weight of any substance upon the Earth's surface.

The rings of Saturn appear to have their own special centres of conductive or cohesive gravitation, supposing each of them to be a continuously connected body: but the body or surface shell of that planet is in subjection to another peculiar centre of *centripetal* cohesion. Between the rings and the surface of Saturn, there is no such centripetal tendency, although they may be mutually amenable to the reciprocally alternating influences of inductive attraction and repulsion; but the possibility of the rings "falling in" upon the surface of the body, cannot be advanced, without imagining that electrical or magnetic *repulsion* is a nonentity in astronomical dynamics.

5. The magnetic phenomenon known by the name of the *variation of the compass,* may also aid us in the attempt to solve this problem, when it is considered in relation to the hypothesis already submitted to the reader, about the probable existence of more than one distinct and detached mass of matter within the apparent circumference of the Sun and the primary planets. We have already supposed the probability, that the planet which we inhabit is composed of an external shell and a nucleus, which are not in contact with each other; should this notion be correct, we find no difficulty in the assumption,—that the magnetic needle is in reciprocity with the *inner* or most dense and heaviest of these two distinct bodies—that what are called *the magnetic poles* of the earth, are those points on the outer body or shell, which are immediately *over the poles of the internal nucleus—and that the variation of the compass is to be attributed to the secular change in the relative positions of the two sets of poles.*

The changes which occur in the relations of the equator and the ecliptic suggest an analogy to this assumed revolution of the poles of the inner nucleus round those of the external shell which we consider the true poles of the earth. All the experiments of Hansteen and Duperry upon the *dip* of the needle, and those of Barlow upon the magnetic properties of a ball or shell of unmagnetised iron, concur in the support of such a speculation; and in the latest voyages of discovery, the south magnetic pole has been determined to be antipodal to that in the northern hemisphere.

It has been stated by one of the most scientific naval officers of France, M. Duperry, that the dip is a constantly increasing quantity as we advance from the magnetic equator to the magnetic poles; and that the nodes of this equator *are exactly opposite each other*, one in the Atlantic, the other in the Pacific, being nearly on the great circle of the meridian of Paris, in 1830. Both Morlet and Hansteen affirmed, that the magnetic equator in the Atlantic is wholly to the south of the terrestrial equator; and that the node is in Africa, where the terrestrial and magnetic equators bisect each other. The difference, however, is not essential, more especially as the nodes move from east to west; so that M. Duperry's accurate observations, made with Hansteen's charts before him, support the general hypothesis of the Norwegian philosopher; while they make the symmetry between the two parts of the equator more exact than had been previously imagined, even by Hansteen.

The magnetic equator, it is true, is a little affected by the neighbourhood of islands, and still more so by the continents over which it passes; but this is corroborative of the hypothesis, that the greater influence of the *internal* or more condensed portion of the earth, is interfered with by the magnetism of the *shell;* while it demonstrates, that the *projecting solid parts* of the shell are capable of generating a greater degree of this counteracting force, than its liquid portions. This may be attributed to a special or local influence depending on the quantity of iron and other magnetic matter distributed throughout the continents, or in the larger islands.

After having considered the hypothesis of an *internal nucleus* being the magnetising body under ordinary circumstances, in reference to the *dip*, let us apply the supposition to the *tranverse variation* of the compass. When an iron shell or ball (which is suspended above a magnetic needle) is gradually lowered, it affects the *south* pole as a disturbing force, which is important as establishing an analogy between it and the magnetic currents on the surface of the atmosphere, or of the outer shell of this globe: but this experiment of Barlow suggests another analogy which aids our endeavours to understand the influence of the internal nucleus itself. He found that the attraction of the south pole towards the *descending* ball, increased *with the descent*, until it attained a maximum; after which, the attracting influence decreased, until it ceased to exist when the descent of the ball had attained another fixed point in relation to the needle. Dr. Barlow inferred, *that in every ball or shell of plain or unmagnetised iron, there exists* A PLANE OF NO ATTRACTION, *or one in which the ball exercises no influence on the magnetic needle.*

Now this is precisely the case as regards the variation of the magnetic needle. If we assume that there is a line between the magnetic poles, in which the *internal* terrestrial body exercises no influence, we can explain why, when a compass is on that line, the needle should arrange itself due north and south in the direction of the *weaker magnetic current* or that of *the axis of the shell.* But the line of no traversing influence, as regards the nucleus, is not *a complete circle*, — deviations being occasioned in this instance, as in that of the magnetic equator, by the inequality of the earth's surface and the nature of the high land, which may contain many special seats of magnetic force capable of disturbing the regularity of the circle.

The line runs with very little irregularity from the magnetic pole in North America, where the dip is 90°, across Hudson's Bay, Canada, the state of New York, the part of the Atlantic ocean between that coast and the most western district of Brazil,—which it leaves at Bahia,—towards the south, over the Atlantic, until it meets the newly-discovered Southern Continent, and reaches the antipodal point of the north magnetic pole, where the dip has been found at or near 90^0 by recent navigators. If we compare this line with that of the great semicircle between the two magnetic poles, we find that there is a slight deviation from it towards the east—as the line ought to touch Barbadoes, and strike the South American continent near the mouth of the Amazons, leaving it at Rio Janeiro instead of at Bahia. Still the deviation is very unimportant; and we may infer that the regular force of the internal magnetic nucleus is interfered with by the neighbouring high land of the American continent, which almost extends from one pole to another. Not so the other half of the great line of *no variation* on the Asiatic side of the world.

According to the best observations, the line of no variation proceeds from the southern magnetic pole to the coast of New Holland, (which continent it traverses from south to north) and then seems to be governed, in passing through the East Indian Archipelago, by the great mountain chains or high land of Borneo, Java, Sumatra, Ceylon, and India: in this respect it holds the same relation to terrestrial irregularities of surface, as it does in the opposite hemisphere to the great American chain: the repulsion of the line however being to the east of the American chain, while it is to the south-west of the East Indian islands and India. The great circle is altogether distorted in these regions. In Dr. Barlow's map it enters India a little above Bombay, and appears again in the China sea, passing in a north-easterly direction between the Japan islands and the Asiatic continent, which it enters obliquely, not far from the Amoor river. It then turns to the north-west, rounding the high lands of central Asia, and after sweeping again in a southerly direction, it assumes a northerly course, leaves the continent near the entrance of the White Sea, passes to the East of Spitzbergen, beyond which towards the north it may be supposed to cross the polar regions and to lead to the magnetic pole in North America.

Now we shall find that the two great curves described by this line of *no variation* in the eastern hemisphere, coincide in a remarkable degree with the two masses of land round which it sweeps; and the inference, that the irregularity of the line is occasioned by the accidents of the earth's surface, induces an opinion, that the mariner's compass is subject to the influence of three general causes of control; namely, the interpolar currents of the *internal* nucleus—that of the same currents on the *external* shell—and that of eminently *magnetic masses* of matter, which are scattered in terrestrial regions rising *above the ordinary level of the sea.* By far the greater portion of the solid layers of the terrestrial shell are covered by the even surface of a fluid, which seems to prevent the subordinate mineral magnets from interfering with the influence due to the internal nucleus, or to the external shell,—both of which are in reality distinct and independent magnets.

The intensity of the magnetic force has been measured with much care by Hansteen; and his observations upon this point mainly induced him to arrive at the conclusion, *that there were four instead of two magnetic poles:* he found, that the intensity of the attraction when measured by the number of oscillations in a given time, indicated the existence of *two* poles in the *northern* hemisphere; he placed the one in America and the other in Asia; and supposed that both were in the same parallel of latitude, and *exactly opposite each other.*

If we make allowances for the deviation occasioned by the American chain, which inclines the line of no variation to diverge a little to the east out of the great circle of the magnetic poles, we shall find that Hansteen's assumed position of the American pole (obtained by calculating the differences of intensity of transverse variation, and of the dip) will coincide very nearly with the point in North America, where it has been found by actual observation.

But when we apply his deductions to the hypothesis of the internal nucleus, the necessity for the existence of *his* four poles disappears. Supposing the Boreal and Austral magnetic poles to indicate the points on the earth's surface, which are immediately over the axis of rotation of the internal nucleus—it is evident that the intensity of the force of either pole would so act upon needles on the surface of the external shell, that it would offer no appearance of uniformity. If, for instance, an observation were taken latitudinally *opposite* the American magnetic pole (under which, we maintain, is the northern pole of the internal mass of matter which partly composes this earth)—*at the point fixed upon by Hansteen for his Asiatic pole*—the needle would be acted upon in a peculiar and complicated manner. It would be in the plane of *no transverse attraction*, as regards the *internal* nucleus; or according to usual language, it would be in that of *no variation:* it would not be affected *transversely* by the nucleus, but it would point due north and south, because it could be only amenable to the interpolar currents of the *external* shell. Still the *dip* would be very considerable towards the pole of the internal nucleus, because the northern end of the axis of that body *would be opposite on the other side of the concave surface of the shell.*

The neighbourhood of mineral magnets in the mountains of the vicinity, would also have an influence in the northern hemisphere, which would not prevail in the southern; thus explaining the fact noticed by Hansteen, that the intensity of the magnetic force was less in the south, where the ocean predominates, than in the northern parts of this globe; while it is obvious, that, under such conditions, his observations about the irregularity of the relations of the dip and of the intensity—are equally capable of being verified by theory.

In addition to these arguments in support of the hypothesis which dispenses with his Asiatic magnetic pole, we may take into account many other conditions, which are as yet unknown quantities ; such are the results of the action of the *external* polar influence upon a needle exactly *opposite in the same parallel of latitude*, as regards the dip produced by the nucleus; and in our computation of such results, it must not be forgotten, that there is a plane of *no attraction* as regards the transverse variation, on which plane this Asiatic pole of Hansteen is placed.

That the Sun has an inductive influence upon the development of the magnetic properties of the earth, is proved by observation; *but this influence, instead of promoting the magnetic currents, diminishes them.* Magnetic intensity is at its *minimum* in June, and at its maximum in December, in our hemisphere, *as regards the year;* and at its minimum when the Sun is on the magnetic meridian during the day. This counteracting effect is in harmony with the great system of *antagonism*, which prevails when inductively promoted gravitation is the result of *reciprocity* between two such bodies as the sun and the earth. We have every reason for believing that the Sun's magnetism is vastly more powerful than that of the Earth, in proportion to their bulks, and for assuming upon general principles, that *his influence tends to lessen the intensity of terrestrial magnetism*, instead of increasing it. Every argument, therefore, is against the supposition that the Earth owes its physical magnetism to the Sun.

That there is a special magnetic superficial impulse converging towards the poles in every body, and that it is occasioned by galvanic impulses which circulate completely round the body at right angles to its poles, seems indisputable. The production of this sort of galvanism is a most interesting subject of inquiry; for this force is not to be confounded with simple electricity any more than with the interpolar currents which it generates. There are evidently many sorts of galvanic currents. A special current may circulate round every particle or corpuscule which constitutes a body; at all events it must circulate round every minute magnet according to *Ampère's* theory: and in that case it must have some *conductive* relations to other bodies with which it is in contact. This necessity has been already noticed in reference to the electrical experiments which explain the inductive chemical processes of nature, when they are hampered by conductive conditions. The most transcendental species of the galvanic energy would be more properly termed geological or astronomical, when, as a semi-inductive superficial current, it flows round a heavenly body unimpeded by atomic matter. But although all sorts of galvanism produce the interpolar currents, and we are justified in classing them under the same general head, there is an independence of position as regards the surface of each distinct heavenly body, which gives an *astronomical importance* to its *general* galvanic and magnetic currents; while those of the separate magnets which are only portions of it, however they may be influential in the balance of attractive power, can only be considered as chemical or subordinate physical phenomena. These minor magnets have an undoubted influence on the magnetic needle, as has been already shown; but the two great terrestrial magnets are the external shell and the internal nucleus of this globe; each of which is, as we assume, a distinct heavenly body separated from the other and from all stars or planets, by regions of ether, or *non-atomic* matter. Their action upon the magnetic needle differs from that of the minor magnets. The internal nucleus of the Earth must be as free from contact with other bodies, as the external shell is; it could not have an independent motion, if it were not wholly detached from that hollow envelope which conceals it from our view; and the independence of its motion is proved, if we admit that its axis, oscillating round that of the shell, causes the precession of the magnetic needle's variation: in this case (as in that of Saturn and his ring), there can be no *conductive* influence.

As regards the external shell, we have every reason for supposing that the seat of its general magnetic influence is *superficial* to the whole body outside the atmosphere. Its action upon the needle is *inductive*, but the induction is of the same mixed nature as that of ordinary electrical induction, which we observe in our experiments *made in an atomic medium.*

Aeronauts have found no alteration in the direction of the magnetic needle when at the height of ten thousand feet above the level of the sea; and at nearly a thousand feet below that level, the miner observes no difference, which would lead us to imagine—that the force which makes the magnetic needle assume a direction parallel to its own current, does not act as powerfully in the middle of the air above as in the solid layers of the Earth beneath. In reality it is neither in the one nor the other of these atomic substances, because it is an agitation of the ether itself, or of the non-atomic coating of an atomic body which generates the influence. When we look to the extreme surface of the gaseous atmosphere for the seat of one general magnetic influence, and to the outside solid layer of the internal nucleus for the seat of the other,—we meet with no difficulty in accounting for all the phenomena of terrestrial magnetism; but we must not forget to take into account the interference of those occasional agglomerations of metallic matter upon the earth, which are so many magnets, capable of disturbing the regularity of the greater magnetic influences of the external shell and the internal nucleus of this globe.

It must also be inferred, that the inner or concave surface of the terrestrial shell has its own *internal* envelope of non-atomic matter which is agitated by interpolar currents, and is therefore a sort of internal ethereal or *non-atomic* atmosphere of the shell, which must be distinct from the mass of ether occupying the interval between the shell and nucleus. A solid body however, such as the nucleus may be presumed to be, can only have an *external* envelope, and in this respect it must differ from a hollow shell, where the atomic aggregate is presumed to have an internal as well as an external coating of non-atomic ether, each of which undergoes its interpolar agitation and has peculiar attributes distinguishing it from the mass of ether which surrounds it, or that general portion which is contained within its concavity.[p]

Now if we apply the analogy of the opposite states of electricity, (which belong to a *charged* Leyden vial), to the terrestrial shell, we may understand that the polarities of the envelopes on the convex and concave surfaces of the shell must have opposite conditions, both of which may exercise an influence upon the magnetic needle: and this will account for many magnetic phenomena independently of the existence of any nucleus, more especially as regards the aurora, which may depend upon some as yet unknown causes connected with the relations between the inner and outer envelopes of the shell itself.[q] It will also suggest, that the *opposite* polarities of the shell and the nucleus, are not those of the envelopes of the respective external surfaces, but of the *internal* surface of the shell and of the *outer* or

[p] The ultimate atom, although hollow, is not supposed, in our general hypothesis, to contain any material substance, but to be an absolute void. Such an hypothesis will not admit of the existence of the internal envelope.

[q] The aurora *borealis* affects the *south* pole of the dipping needle, a phenomenon indicating the predominating influence of magnetic currents generated on the *inner* or *concave* surface of the shell, where the magnetism has polar attributes which are opposite to those of the external surface.

only uninterrupted layer of agitated ether surrounding the nucleus. The result of this mode of reasoning would be the conclusion that the dominant north pole of the shell has the same polarity as that of the north pole of the nucleus.

Unless we adopt this doctrine it will be difficult to explain, why the magnetic needle does not change its poles when it is in the line of *no variation,* and is exclusively affected by the shell; but if such a relation of magnetic polarity be admitted,—it follows, that whether the needle be under the influence of the shell or the nucleus, there will be no manifestation of an *opposite* polarity; in either case there would be the same general appearance of reciprocity, because the corresponding poles of the shell and nucleus, would exhibit the same affinity for the same pole of the needle.

The identity of polarities upon the external surfaces of all the distinctly detached masses which are included within the envelope of any apparantly single heavenly body, would therefore prevail, whether the Sun or any of his planets consisted of only one shell surrounding a nucleus, or of many such shells one within the other, the nucleus in every case being the dominant mass.

The preceding remarks upon the probable causes of celestial orbitual motion, refer them all to one general principle, which is, strictly speaking, an electrical force occasioning the alternate mutual attraction and repulsion of bodies constantly changing their *inductive* electrical relations to each other. One of the most obvious concomitant physical alterations in the physical state of a body, which is sometimes nearer the Sun than at others, would be a change in its calorific conditions. As the planets move in elliptical orbits, the eccentricities of which are comparatively small, they may not undergo consequent variations of expansion and contraction as regards their general bulk, to any perceptible extent; but the comets, whose orbits are for the most part extremely eccentric, ought in accordance with this doctrine to be greatly expanded as they approach the Sun, and condensed as they recede from him; and we can conceive a necessity for the vaporisation of the greater part of the cometary substance, when a comet is at its perihelion, as well as for the gradual change into a liquid or solid state of such vaporized matter, at the aphelion, more especially where the ellipse has the eccentricity of the comet of 1680.

Independently of this variation in its calorific conditions, we can understand that the same law, with respect to inductive and general *anticentripetal* attraction, which promotes the great tidal wave of the earth's ocean and atmosphere,—would determine that the form of a comet should be affected by every heavier body near which it passes, when the greatest portion of its own substance is in gaseous state; and that when near the sun, a cometary body should have the outline of an ellipsoid whose *major axis* would be in the direction of its *radius vector*.

The peculiar appearance of a train or tail in such a case may be an optical illusion. The *nucleus* of the comet may occasion a faint eclipse or comparative diminution of the solar light immediately behind it; and the light reflected from the inner surface of the vaporised substance which would surround this darkened cone, may be *refracted*[r] in such a manner as to affect the eye, which would not

[r] This is shown satisfactorily in the effect produced upon a dense fog at night by the street lamps in London, and still more completely by those in the squares. The light of the gas-lamp in such a case represents that of the Sun,—the corners of each lamp at its angles hold an analogy to the nucleus of the comet,—and the fog may be considered the counterpart of the rarified substance of the cometary body. Accordingly as the observer changes his position, he will see a ray of light produced by the interference of the opaque corner of the lamp. It will move, and increase or diminish in intensity. Should he be exactly opposite the lamp, he will see two distinct and opposite pencils of light in the fog beyond the framework of the lamp,—but immediately around these luminous pencils, he will not perceive any light, beyond a very restricted distance from the central flame.

otherwise perceive any vaporized portion of the entire body. This may account for the tail appearing on the side of the comet the most distant from the sun; and where there are many such trains of light seemingly following the comet, the constitution of the nucleus itself, or of an irregularly formed layer of denser substance than its general external vapour, in the immediate neighbourhood of the nucleus, may occasion many slightly darkened shadows, each of which would be surrounded by its own apparent tail.

It is not however our object to enter upon the difficult problems of the theory of comets, but only to show that we may explain the appearance of what is called the tail of a comet, by applying general principles to the phenomenon, and by supposing that the outline of the expanded comet is an ellipsoid, the gaseous portion of which is only perceptible where it surrounds the shadow of the nucleus. Still it is important to discover a method of explaining that the visible portion of the immense atmosphere which surrounds the nucleus may never be separated from the mass, but may always accompany it as the atmosphere of a planet would do; because the hypothesis that the matter of the tail *flies off* from the cometary mass during its revolution, is contrary to the principle of cohesive or centripetal gravitation, more especially when the whole mass is expanding instead of contracting.

Our modification of La Place's theory about the separation of rings or zones from the Sun, is based upon the assumption that his constituent molecules are constantly undergoing a secular contraction, and that an *external* or *anticentripetal* attractive force hinders all his substance from remaining in a state of conductive cohesion. There are no reasonable grounds for concluding that oblate atoms in that state can be disjoined, unless it be in consequence of an inductive energy of reciprocity with some other heavenly body; but in the supposition that the substance of a comet's tail radiates into space and is dispersed, no attempt has been hitherto made to prove that this is promoted by the influence of gravitation.

The comets of our system may have been originally ejected by volcanoes scattered over the Sun's surface, and such volcanic action may be attributed to *chemical* accidents of juxtaposition, affecting the various and complicated sorts of substance which constitute the Sun himself. It is one of the opinions advanced in the present treatise, that there can be no cohesion between heavenly bodies, or portions of the same heavenly body, which have been completely disconnected in Space. It would be in accordance with this doctrine, that, if the eruptive force of a solar volcano be sufficiently energetic to project any atomic substance beyond the ethereal *envelope* of the Sun,—the matter thus *entirely disjoined*, should thenceforward hold *astronomical* inductive relations of an electrical positive and negative character to the parent body, and revolve round the Sun in an ellipse of greater or less eccentricity. If the dark spots on the Sun's disc be occasioned by volcanoes, which nearly rise above the limits of his luminous atmosphere, a very great force of projection is not required to account for *the annihilation of the force of cohesion* in such a case. Many meteorologists have attributed a far greater energy to lunar volcanoes, because they do not suppose that there is any *defined* limit to the attraction of cohesion.

Our cometary hypothesis has the advantage of attributing the origin and motion of comets to general causes, which are prevalent in the volcanic regions of the earth's surface; while it supposes their orbits to be elliptical like those of all other bodies moving in an ethereal medium. To assert,—that comets pass from one solar system to another, and that they move in hyperbolas,—is to advance speculations which are opposed to analogical phenomena connected with the *known* motions of the heavenly bodies, including those of the comets themselves; for La Place admits that out of a hundred comets, the elements of whose orbits have been observed, not one of them can be satisfactorily proved to move in a hyperbola.

The extraordinary eccentricity of some of these orbits will account for great alternations of expansion and contraction. If the substance of a comet were originally ejected in a gaseous form, the laws of reciprocity in astronomical induction might enforce its consolidation at the aphelion, and its subsequent vaporisation when it returned to its perihelion. If the atmosphere of the Sun be very shallow, the volcanic force necessary for the disjunction of the cometary substance, may be little greater than that of some volcanoes upon the surface of this globe: for when the cohesive influence is once overcome, and a distinct *duality* is established between the Sun and a portion of his substance, in consequence of the eruptive force projecting the cometary matter beyond the solar atmosphere,—the volcanically promoted impetus would drive it from the Sun. The *conductive single* force of centripetal gravitation would be immediately replaced by one of a *compound* and *inductive* character, in obedience to which it would manifest relations of elliptical reciprocity to its parent mass: the original force of projection would sooner or later be overcome by the force of attraction occasioned by the increasing dissimilarity in the electrical states of the two bodies; and the comet would then return to the Sun.

As regards the general question considered in this section, we may conclude,—

1. That the locomotion of every heavenly body is the consequence of its holding inductive relations to some other body, which, like itself, undergoes a continuous change of position in the ethereal medium, because there is a reciprocity of gravitating influence between them.

This influence is propagated in straight lines, but all bodies so excited change their relative positions in elliptical curves.

2. That the eccentricity of an ellipse described by a heavenly body moving in space, depends upon the manner in which its *individuality* was created. Planetary disruption, unaccompanied by the volcanic agency, which (as is presumed) generated the comets, might give the new body such a motion in relation to its parent star, as would almost offer the *appearance* of a circular revolution round it: while the impetus and the *direction* relatively to the curve of the Sun's surface, with which volcanic matter is ejected, will account for an eccentricity equal to that of the orbit of any known comet.

3. That there are no centripetal or centrifugal forces in astronomical dynamics. The practical elliptical orbit with its two centres, is occasioned by alternations of mutual attraction and repulsion; the aphelion being the limit of repulsion, and the perihelion that of attraction.[s]

[s] So much has been already advanced against the doctrine of centripetal and centrifugal forces, that a didactic mode of denying the existence of such *data* has been ventured upon, now that we have advanced to this stage of the general argument.

An ellipse has *two practical centres of force* which are its foci; but the point in which its major and minor axes bisect each other, cannot be regarded as a centre of active influence, although in the diagram it becomes a prominent object, when those axes are described by the pencil or pen of a theoretical mathematician.

May we not attribute the doctrine of centripetal and centrifugal forces to that proneness in the human mind to adhere to old opinions in detail, even when the reason and judgment are satisfied, that in their general scope such opinions are erroneous? All the early ideas of astronomers were connected with circular movements; and the notion of centripetal and centrifugal forces is only applicable to *one* centre, and to a *circular* circumference; but by degrees it was discovered, that the planets moved in elliptical orbits, and the doctrine of two foci was substituted for that of a single centre of action. The centripetal and centrifugal forces appear to be wholly inconsistent with the ellipse; but the great discovery of Newton, which attributed weight to *one general influence* of mutual attraction between bodies, still tended to the maintenance of the opinion, that the *data* or motive basis of the celestial system were centrifugal and centripetal forces.

Newton discovered the uniformity of the conductive centripetal force, which acts *throughout the limited region of space occupied by*

The electrical experiment of the insulated pith ball, which is first attracted and then repelled by the conductor of an electrical machine, offers an explanation of the mode in which the astronomical inductive forces are developed in the locomotion of celestial bodies—the climax of *similarity* in its electrical conditions being attained, when a planet or comet reaches its *perihelion*, while that of its

the substance of our globe; and there is an analogy between certain laws which govern its direction, and these of the inductive sympathetic influences which occasion the motions of the celestial bodies. Moreover, the same *vis insita* is the *primum mobile* in both cases; but the conditions under which it is operative are widely different, whether it acts *centripetally* in its *conductive* capacity, or *elliptically* as an *inductive* force.

Fortunately all the mathematical discoveries of our great countryman and his successors, are theoretical truths, and they are equally applicable in practice, whether the centrifugal theory be true or false: but a new agent, that of electricity, has made its appearance in the philosophical category of causes of phenomena; and to the action of that agent future mathematicians may apply the formulæ which were made use of in building up an astronomical theory, when the *data* of centripetal and centrifugal forces were considered an adequate foundation for the superstructure.

We must, however, carefully avoid the error of generalising too much *in details;* if the centripetal force was improperly made available in accounting for the motions of the heavenly bodies on one side —the laws of locomotion in space (where there is no atomic medium), were erroneously applied to bodies moving in an atomic medium. It is a maxim that if any terrestrial body falls towards or upon the earth's surface, there is a real, although imperceptible, movement of the whole globe towards the body so falling upon it, and this maxim is based upon the phenomena of a mutual attracting influence between heavenly bodies, or between separate portions of the atomic matter which composes any one heavenly body. Yet notwithstanding such an appearance of accumulated evidence in favour of the opinion, it seems impossible that the earth should have any motion in space as a whole, in *consequence of the change of position of any of its parts*, unless they are altogether detached from its atmosphere, and separated from it by an intervening non-atomic medium of ether, as in the case of the moon.

Conductive attraction occasions the tendency of all the constituent parts of a body to cohere and to press towards a common centre of gravity, which is somewhere within the space occupied by the body: but the complicated force which produces a mutual action between separate heavenly bodies and induces their curvilinear motions in space, acts through the medium of a non-atomic ethereal fluid; therefore there is no analogy between the influence of the moon upon the earth, and that of a rock falling from a high precipice *within our atmosphere.* There may be a mutual influence of attraction between two corks floating in a basin of water, which moves them both; for they are distinct parts of the terrestrial body; but between *that entire body* and one of its portions *dissimilarity* determines its return, when it is at the *aphelion*.[t] These climacteric conditions correspond with the

there can be no such mutual excitement, capable of occasioning the motion of *both objects*, because the body itself occupies the whole region in space *within which* the rock falls from the precipice: every other mechanical or chemical action belonging to it, must occur within the same region.

[t] A comet with a very eccentric orbit may be selected as the best exemplar of the hypothesis of mutual gravitating influences; while the electrical experiment of the pith balls, which are first attracted and afterwards repelled, is capable of furnishing an argument against the popular theory of centripetal and centrifugal forces.

Supposing the comet to be at the *aphelion*, when the force of the *repulsion* had ceased, that of attraction would induce its return to the sun: during this movement its electrical state would be gradually changed by induction, and upon its arriving at the perihelion, the climax of change would promote a contrary impulse of repulsion capable of driving it round and from the sun, until its general condition was again such that it would return to its perihelion.

It must be borne in mind, however, that the so-called *inductive* changes in the electrical state of any heavenly body are entirely dependent upon its relations of proximity to another body, and that they are altogether transient or temporary; not so the changes in the conditions of the pith balls, when they approach the conductor of an electrical machine: they acquire an absolute increase of electricity, because they are surrounded by an atomic medium of circumambient air, which acts *conductively* between them and the machine, as well as *inductively*. This permanent increase of their electrical properties will be retained, until it is discharged through the same medium by which it was conducted; and thus far the similitude appears to be incomplete; but as the ethereal medium between the two heavenly bodies is incapable of conduction, we only look for an analogy in that part of the phenomenon, which is the result of a *sympathetic* or inductive, not of a conductive, influence.

Together with the other experiments by which the phenomena of induction have been demonstrated, this alternation of attraction and repulsion in the balls completely explains the whole theory of the elliptical motion of the heavenly bodies; and the general law of attraction which measures its intensity by the distance, is made manifest in cometary motion by the variations in the *rapidity* of the comet's movement, in approaching towards, or returning from, the sun.

As the *inductively*-occasioned expansion of any body is the production of the same general agitation of the medium as that which produces inductively-occasioned gravitation, we are justified in supposing that there is as great a variation in the expanding as there is in the gravitating conditions of the comet during its revolution. As it approaches the sun, its general bulk would be dilated; as it retires, the size would be diminished and the particles of the comet's body would be proportionally consolidated: during its journey from the aphelion to the perihelion, it ought, according to all analogy, to change its state from that of a solid to that of a liquid, and eventually to that of a gaseous body: on going back to the aphelion point of condensation, it must pass through the phases of a return to a solid body.

All this is in accordance with the fact; the comet moves with a greatly increased rapidity when positive and negative states of the constituent portions of a single heavenly body; but they are occasioned by more complicated causes, and the intensity of its inductively produced positive or negative qualities, depends upon each planet's or comet's original, as well as its present, relations to the Sun.[u]

near the sun, and its substance dilates to such a degree, that the extent of its volume is only perceptible on its return, in consequence of the optical illusion, which is called its tail. That the tail of a comet is a luminous appearance of a diameter or radius of its spheroidical substance, in consequence of the refraction of the sun's rays, is a perfectly consistent solution of the difficulty; and that some comets are so constituted as to have no tails, may be evidence in favour of their being less dilatable than others. The whole argument militates against the idea, that the comets can ever *fall into* the sun.

The length of the tail of the comet of 1680 was forty-one millions of leagues, during a short time when it was returning from the sun: the cometary body was therefore larger, or occupied more space, laterally, than the sun itself. Yet its centre of gravity ought to have passed within one-sixth part of the solar diameter from the sun's surface, and the two bodies must have been in contact, if such contact were possible. We must, therefore, suppose that the force of repulsion (at that moment) so acted upon the gaseous portion of the comet, that its oval form was entirely interfered with. Not only did the comet return, but its motion did not seem to be impeded by this proximity.

[u] The disjunction of a zone of vapour from the atmosphere of a heavenly body cannot be an instantaneous process: it must occupy a certain portion of time, and the rent or crack would gradually extend itself from the weak point, or that where the expansive force overpowered the centripetal cohesive force, until it went round the body. The eccentricity of the ellipse, in such a case, would depend in a great measure upon the comparative length of the period occupied during this operation of nature, and the consequent disturbance of the equilibrium before the separation was complete.

The original condition of cometary bodies, if they were, at first, *columns of gas* ejected from volcanoes, must have differed from that which they would assume afterwards. But the result of this difference between the primeval and subsequent conditions of a comet need not affect the eccentricity of its orbit: before the column arrived at its aphelion, according to the general law of opposite electrical states, which converts it into a solid, it would have become gradually shortened, and, at last, agglomerated into a spherical body: and in its future alternations of expansion and contraction, the spherical or spheroidical form thus attained would have been again lost, and again resumed. Thus the eccentricity of the cometary orbit would depend mainly upon the impetus and the direction of that impetus, as regards a complete diameter of the sun. By as much as that direction approached the character of a tangent to the sun's surface, by so much would the orbit resemble the circular form; while, on the contrary, the eccentricity would be so much the greater, as the direction of the propulsion approached a perpendicularity to the surface of the parent body.

SECTION XI.

On the phenomena of terrestrial magnetism.

It is difficult to avoid confusion in treating of magnetic influences, because the appearance of those gravitating energies which magnetism directs and controls, is the only evidence in favour of its existence, when inorganic matter alone is the subject of our examination. This is the more likely to happen, as the poverty of all languages in reference to scientific improvement, renders it necessary to invent new terms, or to be extremely careful how we make use of old ones; and it has been the object of the author to avoid this sort of invention, where perspicacity may be attained without it.

The word "magnetism" in the present treatise is always intended to convey the idea of a *physical manifestation* of the power which enforces order, direction, control, and arrangement. The power itself is not a physical force, but an impersonal instinct; yet the author has found it almost impossible to adhere strictly to his own rule in treating of such formal modes of the development of Nature's laws, as the interpolar currents, or in describing those distinct bodies usually termed magnets,—without confounding the *quasi-intelligent* impulses of magnetism with the physical motions which they control.

Every *individualised* portion of the universal ethereal substance, be that individual a single atom—a simple particle composed of atoms—a corpuscule consisting of dissimilar particles—an inorganic body, or a chemical congeries of such corpuscules—an astronomical body consisting of many different chemical bodies—a vegetable—or an animal —is really a perfect magnet, however vague such a general term may appear. But the intensity of its magnetic relations to other bodies, and to the expansive and gravitating energies (of which it is the instrument of power over other bodies, or in subjection to which it is governed by them), must depend upon an incalculable number of successive chemical and astronomical predetermined events which occur in obedience to the great magnetically administered laws of an Omnipotent Intelligence.

A magnet, however, according to conventional language, is a body, the constituents of which are so arranged, that it sympathises with other bodies visibly, in consequence of the mutual reciprocity of their *gravitating relations;* but according to our more enlarged definition, one body may have magnetic relations to another without the manifestation of any of those locomotive changes, which indicate the existence of gravitating affinities between them. Still in the following remarks, the term "magnetism" will be chiefly employed in its *conventional* meaning, which implies the co-existence of physical gravitation. General interpolar magnetic currents exist in all heavenly bodies; and as there is no question more interesting in physics than that of terrestrial magnetism, it is now proposed to examine the connexion between the galvanic and the so-called magnetic currents, treating them both as mere physical developments of different species of electrical forces.

When a galvanised conducting wire is made to pass through a heap of iron filings, it becomes an attracting body, and coats itself *evenly* with them; but they cease to adhere when the galvanic circuit is broken. On the other hand, a permanent magnet (also an attracting body), affects the filings in a very complicated and uneven manner, and those which adhere to it, remain fixed until they are brushed off. In one case, it is merely a *passing force,* which endues the attracting wire with its virtues; in the other the attracting magnet appears to possess an *inherent* quality: but if the temporarily influential galvanised wire be brought into the immediate vicinity of a magnetic needle, and be placed either above or below it, the needle or permanent magnet arranges itself at right angles to the temporary current. Hence we infer the existence of a decided difference between the so called galvanic and magnetic currents, not merely in regard to artificial magnets, but to the great interpolar currents of terrestrial magnetism, parallel to which the needle arranges itself, when undisturbed by the action of any irregular influence. Moreover, it has been found that the galvanic current affects unmagnetised needles in two ways: those needles which are attached to a conducting wire *longitudinally*, are endued with an uniform but merely *temporary* power of attracting iron filings, while those which are attached to the wire *at right angles* to its length, attract irregularly, but they become *permanent* magnets after their removal. The experiment proves, that either sort of magnetism is a secondary and dependent force in relation to the galvanic action.

These simple facts, for the knowledge of which we are indebted to the Danish Professor Oersted, in connexion with the more recondite discoveries of Dr. Faraday about the *rotation* consequent on the mutual influence of the magnetic and galvanic forces, appear to justify the hypothesis of M. Ampère, who supposes that magnetic properties are generated by electric currents, propagated around a magnet perpendicularly to its axis; and in accordance with this notion, he considers the Earth itself to be a magnet. This opinion coincides in every respect with the general synthetical method advanced in the present essay.

Some of the striking phenomena in relation to the magnetic influence, are those connected with *rotatory* motion; and many attributes of secondary heavenly bodies might appear to imply a necessity for the rotation of the primary congeries of atoms, from which they have emanated; but polar magnetic currents in any celestial orb or distinct mass of matter (be it primary or secondary), must be attributed to some cause connected with the separate existence or special individuality of the planet or satellite itself. This magnetic polarity may indeed be modified by the influence of neighbouring heavenly bodies, more especially when the disproportion of bulk is so great as that between the Sun and one of his planets; but it is not possible that the polar currents and rotating motion of the Sun should be due to planetary influence. If these properties of the Sun were maintained in consequence of some reciprocity or sympathy between him and some fixed star, the Earth and every other planet of his system would experience the effects of the external interference, and manifest them in some unaccountable perturbations. It follows, therefore, that his magnetic current must be generated by the action of a force or set of forces of his own. It has also been found, that although rotating discs have a sympathetic influence upon magnets, they will not *generate* magnetic properties or convert unmagnetised bodies into magnets; neither will they communicate the rotating sympathy to bodies which have not been previously magnetised.

When we apply the analogy to all heavenly bodies, the necessity for a special magnetic system in each body is incontestible, even supposing the rotation of a planet depended in part upon the influence of the Sun, which assumption, however, has been already argued against in the preceding section. Different metallic discs, whether the difference consist in the sort of metal of which they are made, or in the broken or unbroken state of their surfaces, influence the same magnetic needle with different degrees of intensity. A disc of tin has only half the power of one of copper; a disc of lead has only half that of one of tin, admitting their sizes and the rapidity of their rotations to be equal in all cases. Hence it appears, that this influence of sympathy is far from being a simple mechanical power depending on the weight or gravitating energy of the rotating body, as the mathematical astronomer might expect it to be; while it is so far mechanical, as to interfere with the chemist's or mineralogist's calculations, when the continuity of the surface of the disc is broken. Moreover, the mechanical experiment is made within an atomic medium, while all sympathies between the heavenly bodies must be maintained by the intervention of the non-atomic ether; and although they belong to the same class of phenomena, inasmuch as an inductive influence is at work in both cases, it is probable that the rotating motion in the magnets could not have been produced by sympathy, without the aid of *atomic conduction.*

Supposing, however, it were proved that the present rotation of the rings of Saturn were the continuation of that of the body of the planet with which they were formerly connected cohesively or conductively, the original rotation of the Sun might be deemed sufficient as a simple *mechanical* cause for the rotation of every portion of his body which has been or will be detached from him. But when the influence of rotating solid or hollow iron spheres upon the magnetic needles, is contrasted with that of one rotating heavenly body upon another, the result leads us to infer, that there is no analogy in the case. The influence of a rotating hollow sphere, or globular mass of metal, does not depend upon its relations to the magnetic meridian, when it changes the bearing of a magnetic needle, which will place itself at right angles to the axis of the shell or ball, *both at the poles and at the equator* of that revolving body. This result differs altogether from the action of the *terrestrial magnetic force* upon the dipping needle. On the earth's equator there is no dip under ordinary circumstances; while, at the magnetic poles, instead of arranging itself at right angles to the earth's axis or across the poles, as it does on the terrestrial equator, the needle dips perpendicularly.

Thus the magnetic needle, under the influence of a rotating sphere of metal, dips at its equator, but is balanced horizontally by the rotation of the *artificial* globe, when it is placed over either of that globe's poles. *Per contra*, the same needle dips at the magnetic poles, but remains horizontal at the magnetic equator, of the *natural* globe. If there were any analogy between the influence of the rotation of the Sun upon the Earth, and that of a rotating shell or ball upon a magnet, we ought to find the axis of the Earth at right angles to that of the Sun, instead of being parallel to it; and if the analogy could be instituted between the influences of the *natural* and *artificial* rotating globes (in the case of the comparison between the iron shell and the Earth), the magnetic needle ought to dip at the Earth's equator, instead of at the poles.

In some respects, the deflecting force manifested in the rotation of the shell upon the *magnetic* needle, resembles that of a galvanic conducting wire upon a magnet; but the galvanic energy can endue a non-magnetic needle with the magnetic virtue, which an iron sphere in rotation is incapable of doing, although it has a directing power in some respects like that of the conducting wire; because the north pole of the needle is attracted, if the upper part of the metal globe rotates towards it; while the attraction is shewn at the needle's south pole, if the rotation be in the opposite direction. This holds an analogy to the change of the needle when placed above or below the conducting wire: if the galvanic current be above, the north pole of the needle turns towards the west; if the current be below, the deviation of the same pole of the needle is towards the east.

Now all these phenomena are in perfect harmony with each other, if we suppose the magnetic interpolar currents of each heavenly body to be generated by an electric latitudinal energy special to the body itself, which is developed in consequence of secular changes going on in its minutest constituent parts. The theory of M. Ampère is indeed based upon this supposition : he believes that electric currents circulate round each constituent particle of a magnet, (the Earth being one collective magnet), and that they produce a consentaneous effect, which becomes that of a general current going round the circumference of the whole magnet.

But it is probable, that there are two opposite currents of this galvanic influence, circulating round every heavenly body. We have already discovered cogent reasons for supposing, indeed, that as regards *terrestrial* magnetism there must be *three* or *six* such currents.

The strongest argument against the rotation of the Sun having any important influence upon the magnetic currents of the earth, is found in *the phenomena of the variation and dip of the magnetic needle.* The theory of Hansteen, in which there are four magnetic poles, may, at first sight, appear to be in favour of a joint solar and lunar influence being the cause of the currents ; and such an assumption has been made the basis of a general hypothesis, according to which the superior planets would each have as many magnetic axes as they have satellites, besides the one depending on the influence of the Sun. But the position of the magnetic poles in our planet is not the same as that of its equatorial or ecliptical poles ; and there is no analogy between the changes of the magnetic poles, and that very slow terrestrial change which occasions the precession of the equinoxes. The periodic numbers of the years fixed upon by Hansteen, as those of the revolutions of his magnetic poles, are 1740, 4609, 860, and 1304 : the irregularity observable in these periods militates against the idea, that they can have to do with the four poles of two axes, although he considers his four magnetic poles to be such,—the two strongest belonging to one axis and the two weakest to the other,—and he supposes that they may either have been congenital with the Earth, or developed at some later epoch, in consequence of the electrical changes produced by the action of the Sun upon the Earth.

It has been already shown, that if we apply the hypothesis advanced in our modification of La Place's theory to this question, and admit that the crust of the earth is a spheroidical shell entirely disjoined from the internal nucleus,—the supposition may account for four poles, two belonging to one axis and two to the other. It is part of our general scheme of disruption, that the outside shell and internal nucleus of a planet should rotate under separate conditions, in which respect they would resemble Saturn and his rings: also that the difference of rotation might *extend to a difference in the inclination of their axes*, supposing there had been any irregularity in the separation under the poles, and that it had occurred between one pole of the shell and that of the nucleus, before or after it had taken place at the other, so that when the separation was complete, the two bodies were not concentric. This condition, however, must be considered under the supposition, that the separation was as complete *at last*, as that between the Earth and the Moon, and that all the inductive relations connected with such phenomena as *the precession of the equinoxes, or the nutation,* would be occasioned by the differences between the external shell and internal nucleus, because their respective axes of rotation are not parallel, and the times occupied by their respective rotations are not alike. Independently of these irregularities, there would be the development of an elliptical motion most difficult to determine, as soon as the *conductive* connexion between the two bodies was at an end: because they would have locomotive relations of duality to each other, unlike any hitherto submitted by astronomical speculation to the test of theoretical mathematics. Thus we have the accidents of possible differences, 1st, in the direction of the axes of their rotations; 2ndly, in the quickness of their rotations; and 3rdly, in their elliptical locomotive relations to each other (to establish which satisfactorily, would require the highest mathematical knowledge); all three being possible causes of magnetic variation and of other apparent irregularities, and each being more likely to promote such seeming anomalies, than the assumed solar and lunar influences.

If, for instance, the non-atomic space within the Earth's outside shell, were much larger than the internal nucleus, and the more condensed portion of our planet were undergoing the double motion of changing its position within it, while it rotated, having an axis at a different inclination from that of the external shell, and with a different degree of velocity, besides possibly oscillating round that other axis, as the equatorial pole does round that of the ecliptic, —there may be a *nutation* accounting for those periods of Hansteen, which cannot be explained by referring to the relations between our globe and the Sun or Moon. But with such recondite mathematical possibilities and undetermined problems before us, it would be presumptuous to advance further without having considered the questions in *pure* mathematics, which they involve. The phenomena of the *dip* may, however, elucidate the main question at issue, namely, the reasons why the Earth's magnetic poles are not identical with those of the terrestrial equator or of his ecliptic.

The most important of these phenomena is the fact observed by Hansteen, that the *south* pole of the dipping needle follows the beams of the aurora *borealis*, as they advance towards the south; because this demonstrates that a new and distinct power, entirely opposite to that which occasions the *ordinary dip* of the needle, acts occasionally upon it. As great magnetic changes are effected by the electric fluid when it is condensed in the clouds, and the needle varies with alterations of their position, we are justified in expecting extraordinary causes for the *decrease* of the dip in connexion with the rays of the aurora, and in treating them as occasional interferences with regular magnetic influence.

When it is admitted, that the visible aurora is the superficial ethereal current, which passes between the poles of the shell of this globe above the least heavy layer of the earth's substance, or the outside of its atmosphere,—the argument is in favour of that current promoting an abnormal force, or one opposite to the regular magnetic energy, which makes the north end of the needle dip towards the *north* magnetic pole. Now if there be an internal nucleus which is separated *inductively* from the external shell, it would be a separate magnetic body: and, as we have seen that the axes of the two bodies need not be parallel, it is a reasonable inference, that two opposite directions of the magnetic force should be made manifest upon the surface of the shell of this globe, both of which may act upon a needle.

Barlow's experiments upon the respective influences of a rotating shell and a rotating solid ball of iron, as regards the deflection of a needle, coupled with those which he made with a ball *at rest, suspended over a needle*, satisfied him that although the magnetic action was superficial, yet a degree of thickness in the shell was necessary, in order to give the maximum of the magnetic force; and although these experiments were made with iron, the most magnetic of all substances, it may be inferred that the power is proportioned (in a certain degree) to the quality of matter which composes the influential body, as much as to the space which it occupies. According to this law, the inside ball or nucleus would be the *dominant* body, and its influence would act upon the dipping needle *in ordinary circumstances;* while that of the inside surface of the shell (which is manifested visibly to us in *this* hemisphere as the aurora borealis) would be principally concerned in the promotion of those *occasional* perturbations of the dipping needle, which coincide with the extraordinary activity of the aurora,—if, as we have reasons for believing, its visible beams be indicators of the self-adjustment of the balance between the electricity, which is generated on the *outer* surface, and that which is generated on the *inner* surface of the terrestrial shell. It follows also, (reasoning by analogy), that the outer currents of the aurora converging at the *south* pole of the shell, are the indicators of those inner currents, which converge at the *north* pole of its internal surface, and that consequently the *south* pole of the dipping needle is depressed by them, when the action of the aurora is more than ordinarily intense, and interferes with the dip,—in other words, with the *polarity induced by the nucleus* at other times. This explanation of Hansteen's fact, about the aurora affecting the dip, is the more satisfactory, as it tallies with the hypothesis accounting for the progressive motion of the variation, and for the *magnetic* poles not being identical with those either of the equator or of the ecliptic of the outside shell; while it tends to demonstrate that which has been only advanced speculatively, in regard to the existence of an internal globe or spheroid.

In addition to this very important truth regarding the connexion between the decrease of the dip and the advance of the aurora borealis towards the south, we find Dalton's observations coinciding with the hypothesis above stated. In his *Meteorological Observations and Essays*, he affirms that there are transverse arches at right angles to the meridian beams of the aurora, but that the meridian beams *alone* affect the dip, and that they must mount several degrees above the horizon, before the needle is disturbed ; while the disturbance is considerable when they reach or pass beyond the zenith. His observations, however, had for their principal object the *transverse* oscillations of the magnetic needle; and they proved that it oscillated sometimes to the east, sometimes to the west of its mean daily position; recovering that position, however, as soon as the action of the aurora ceased,—from which we may infer, that the magnetic currents on the surface of the Earth's atmosphere, not only act vertically upon the needle, but that they affect its variation, by as much as their intensity is to the east or west of the meridian line. Hence it would appear, that the beams of the aurora are distinct occasional jets, having various degrees of intensity, which act more or less perpendicularly and more or less transversely, upon the ordinary position of the needle, as they are more or less parallel to the meridian of the place of observation. Hansteen also says, *that during the continuance of the aurora borealis, the intensity of the ordinary force of terrestrial magnetism seems to diminish;* this observation offers another proof in favour of our hypothesis, that an occasional and unequal development of the *counteracting* magnetism of the external body would debilitate the ordinary magnetic influence of the *internal* nucleus.

The latest observations in terrestrial magnetism demonstrate the existence of periodical changes in the oscillations, which depend, to a certain extent, upon the positions of the Sun and Moon in relation to the meridian of the places where the observations are made; but there are other periodical oscillations which are not to be thus accounted for. May we not conjecture, that they are in some way connected with the diversified constitution of the terrestrial nucleus itself, and that the passage of certain highly magnetic regions of that internal body under the meridian, influences the needle upon the surface of the external shell? If the internal body does not revolve upon its axis, or if the rotation be slower than that of the shell, any given point on the surface of the external shell would constantly pass over such highly magnetic regions of the nucleus at regular epochs; and although the perturbations thus induced might not interfere in any considerable degree, with the general influence of the polar currents of the nucleus, they might be perceptible, and have a periodical effect upon the needle which would resemble that irregular transverse oscillation observed by Dalton, and wholly attributed by him to the occasional influence of the aurora.

In the above remarks upon the *terrestrially* promoted currents of magnetic forces, (whether they proceed from the *external* surface of the shell of this planet, or from its *internal* surface, or from the surface of the within-contained nucleus), it is not intended to affirm that the Sun and Moon do not concur, to a limited extent, in modifying the effects of these forces upon the magnetic needle. They have an undoubted influence upon it, and that this should be shown by an apparent *diminution* of the ordinary intensities of terrestrial magnetism,—is of importance in a theory of magnetism; because such phenomena imply that the magnetism promoted either by the Sun or Moon interferes with the normal magnetic phenomena occasioned by the terrestrial currents, and that it may, sometimes, entirely nullify their influence.

SECTION XII.

On the magnetic influence of the Sun and Moon, and the great superiority of that of the Lunar spectrum, when compared with the energy of terrestrial magnetism, which it is capable of annihilating.

WHEN the inductive influence of the Sun or Moon acts upon the matter constituting the surface of this globe, the most unobserving person is sensible of effects, in many respects similar to those produced by the influence of chemical changes, which depend upon terrestrial causes alone. Heat, light, and a gravitating energy, may be generated upon the Earth without the assistance of the Sun or any other heavenly body; and it seems probable, that there is no difference between the *basis* of the intense light produced by our chemical experiments and that of the Sun's rays. Still, the physical excitement occasioned by the inductive sympathetic energy of the Sun, even supposing its results were specifically like those produced by chemical experiment, must interfere with the simple terrestrially-produced course of events, and give rise to an occasional chemical action upon the Earth's surface, capable of disturbing the regularity of its *conductively-*occasioned changes. But the influence of both solar heat and light, differs considerably from that produced upon the Earth by any chemical experiment of our own, or by any natural terrestrial process hitherto observed; and when we reflect on the complicated method of excitement, to which the sympathetic relations in question between the Sun and the Earth must be due, we only reason consistently in supposing—that there is at least as great a superiority in the influence of the Sun's rays over those of any common source of heat and light within our atmosphere, as there is between the interpolar magnetic current and the galvanic energy, of which it is the offspring.

Not only may it be supposed, that the sympathy between the heavenly bodies is capable of stimulating particles and corpuscules of *terrestrial* matter to develope the same chemical relations to each other, as those which they would exhibit, when subordinate changes of position are produced by our artificial interference with terrestrial causes and effects—but that a new order of influence, which is one of *magnetism* in a more restricted meaning of the word, is hereby developed. This may be proved most satisfactorily, by submitting the magnetic needle to the influence of refracted solar or lunar rays.

The first discovery of magnetic rays in the solar spectrum, is due to Dr. Morichini, of Rome, who found that some needles had been converted into magnets in consequence of their being left in a part of his laboratory or observatory, where they were exposed to the action of a prism: this suggested some experiments, upon which he established his doctrine that the *blue* and *violet* rays possessed the power of producing magnetic properties in needles. But his general proposition has been contested by other natural philosophers, who have failed in obtaining the desired result, when they adopted his mode of proceeding.

The author being desirous of satisfying himself upon this question by actual experiment, found that,

1. A common sewing-needle placed with care upon the surface of a cup of water, and floating upon it, developed a polarity without the intervention of any prism, by arranging itself gradually in the plane of the magnetic meridian, *with its thinnest part or point towards the north, and its head, or thickest part, towards the south.* The experiment was frequently repeated, and the result was always the same, except in one instance, when the head of the needle was very thin : the inference being, that the polarity of the needle was governed by a law, which made that end having the least bulk a north pole.

In most of the experiments made by others, with the view of testing Dr. Morichini's doctrine, the needle was placed upon a piece of cork, if intended to float, or it was suspended in the air by a hair or thread. The method adopted by the author avoided the expense of force, which although trifling as regards the torsion of the thread or hair, might yet be sufficient to occasion failure in the experiment; when the whole needle floated on water, in accordance with one of the simplest laws of hydrostatics, the change of position took place without the intervention of a third sort of substance acting either as a suspensor from above the medium, or as a sort of raft upon which it floated on the water.

2. The needle was taken out of the water, and then placed upon a table in the *blue* rays of the prism for about five minutes. Being again made to float on the water, it assumed a polarity opposite to that abovementioned, namely, with the *head* of the needle towards the *north*, and the *point* towards the *south*. This experiment repeated in various ways with fresh needles, always gave the same results.

a. The point was placed in the blue rays: the head in the red rays.

b. The point was in the extreme violet rays: the head in the dark space beyond.

c. The needle was placed longitudinally in the blue or violet ray.

d. The needle was also placed longitudinally in the red ray.

The change, however, was effected more rapidly, when the influence of the blue rays acted upon the needle, than when it was placed in the red rays; but in all cases the head of the needle became the north pole, although it had been the south pole previously.

3. When two needles, previously acted upon by the prism, were placed near each other upon the water, (the head of one being near the point of the other) their first movement was one of mutual attraction, producing contact between the opposite poles which were nearest each other; then followed a lateral and necessarily curvilinear movement of the unconnected poles until the needles became united, so that they formed one bar, *apparently* exhibiting a complete circuit of magnetic influence. But no sooner had they been brought into contact bodily or laterally, than a peculiar sort of oscillation manifested itself, and they were observed to slide backwards and forwards alongside each other several times, with a rapid darting kind of motion, until they had obtained an equilibrium; the two

needles then adjusted themselves as if they were one, in the magnetic meridian, according to the general principle which compelled the compound pole having the greatest quantity of metal to point towards the north, when both needles had been exposed to the prismatic influence.

It was likewise observed, that the tendency to unite was much more obvious, when the needles were so placed separately at first upon the water, that the opposite poles were near each other, than when the proximity existed between similar poles: but when the two needles were in contact side by side, with their heads together at one end, and their points together at the other, their cohesion seemed more intense, and it was more difficult to separate them, than when the opposite poles were in contact.

The inference deduced by the author from these phenomena, was, that there is no magnetic *circuit* in bodies, but that the interpolar action in all magnets is *limited* by its two ends, between which there is a secondary agitation of their ethereal envelopes, totally different from that circulating galvanic action which creates the magnetic current itself.

4. Three needles which had been magnetised by the prism, were made to float upon water, and arranged in the form of an equilateral triangle: only one of them could be in the direction of the magnetic meridian; and as soon as one of them had so arranged itself, they all remained tranquil. After they had been in that position for some time, they were taken from the water and laid aside; care being taken to mark their position, when they were arranged triangularly, so as to remember how each of them was situated.

Twenty-four hours after they had been removed from the water, it was found, that the needle which had been in the direction of the magnetic meridian, *retained its new prismatically-occasioned polarity*; another had *regained its* *original instinct* of adjusting itself with its point towards the north ; but *the third had lost both its polarities*, and did not adjust itself in the magnetic meridian.

This experiment proved, that there was no *magnetic circuit* in the triangle ; and it is a reasonable inference, that the apparent *demagnetisation* of the third needle which had been arranged nearly at right angles to the magnetic meridian, was an operation which had converted it into a vast number of subordinate magnets—the axes of which were in the plane of the magnetic meridian, during its own transverse position as regarded that meridian. It is comprehensible, therefore, why the point and head of that needle should no longer be magnetic poles, in relation to the terrestrial axis.

The other needle, which had regained its original polarity, had most probably done so, because its point was directed towards the north of east, during its service as a portion of the triangle. A fourth needle, exposed to the prismatic influence simultaneously with the three above-mentioned constituents of the triangle, and afterwards made to float alone, without being in contact with the others,—had not lost its new prismatically-reversed relations to the magnetic meridian: it still floated *with its head towards the north.*

5. On replacing these three needles in the water in a triangular form as before, the triangle gradually assumed its previous position: the needle which retained its prismatically-reversed magnetic tendencies, adjusted itself with its head towards the north, and of course the others came back to their original position : this result may either have been due to the joint tendencies of all the needles,—or it might suggest that the most powerful cause of the re-adjustment was the inductive influence of the terrestrial current upon that needle which had been previously parallel to the magnetic axis of the Earth.

The above experiments, however, removed all doubt about the truth of Dr. Morichini's doctrines; and it is probable, that those who have disputed it, had not produced a sufficient force to twist the thread or hair by which a needle was suspended, or to move the cork on which it was made to float.

Enough attention has not been given to the *lunar* spectrum. No experiments upon the reflection of solar light, heat, or magnetism, where the whole process occurs in an atomically composed atmosphere, will explain the action of the *reflection* of the solar beam from the moon's surface *through the ethereal medium*, because we know from experiment, that the reflected moon-beam conveys no heat, while the artificially reflected ray of the Sun conveys both heat and light.

The analogy between the order of the rays in the solar spectrum and the probable progressive development of chemical and physiological phenomena, in relation to the general theory advocated in the present essay, suggests,—that during the contraction of the atoms which constitute a body, the heat generated by their individual pressure on the ether, is a constantly diminishing quantity. But light itself may attain a climacteric degree of intensity,—after having passed which, the atomic body may gradually lose its phosphorescence.[v] Yet the *magnetic* quality of atoms, according to the same method of argument, is a *constantly increasing* force; and we arrive at the evident conclusion, that the decrease in one case, and the increase in the other, are considerably *hastened* by the process of *astronomical reflection*, because the change in regard to heat is so great, that if heat exists at all, it is imperceptible in the moon-beam. Moreover the reflected lunar light

[v] The reasons for advancing this doctrine about light, will be detailed in a subsequent section.

is much fainter when compared with that of the Sun, than reflected light is within our terrestrial atmosphere, when both the reflecting body and our eyes are indirectly in contact through the medium of atomic air: and we can easily compare the intensity of the *incidental* ray with that of its *reflected* counterpart in both cases.

It follows from the above considerations, that if the force of lunar gravitation be a constant quantity, or nearly so, when allowance is made for the elliptical orbit of the moon, while heat is altogether absent in the reflected moon-beam—we are justified in concluding that *astronomically reflected light* is unlike the heating, illuminating, and other forces generated by the *direct* inductive action between two astronomical bodies. This conclusion perfectly accords with the hypothesis, that the cause of gravitation differs altogether from that which occasions light, and explains still more satisfactorily than has been already done, why it is necessary to distinguish between the light-producing, and the attractive or repulsive forces.

It was with the object of detecting the *magnetic force*, which ought therefore to be more intimately connected with *astronomically reflected* light, than with that which emanates *directly* from the Sun,—that the author made prismatic experiments upon floating needles under the *lunar*, instead of the *solar*, beam. His general theory attributed a much more powerful magnetic influence to the *indirect* reciprocity between the Sun and the Earth through the reflecting agency of the Moon's surface, than to their *direct* reciprocity. His *first* impression while meditating upon the inference was, that *light* had special magnetic qualities, and that when that *phosphorescent energy was reflected* astronomically, it was more influential because it was not then mixed with the heating and gravitating forces. But when the phenomena of the solar spectrum were considered in relation to this separation of light, heat, and gravitation, in the moon-beam, and it appeared that the so-called chemical and magnetic rays might be devoid of light,—an entirely new hypothesis suggested itself.

The experiments on the needles already noticed, proved, that their tendency to arrange themselves with their *points* towards the magnetic north pole, was exchanged for one which placed their heads in that direction. There was no other change than a new distribution of the general inductive sympathy between the terrestrial *magnetic* currents and those of the needles in question: their poles only were changed: and it became evident, that there was no increase in the power of the gravitating force, although the magnetic rays of the Sun appeared to give the needles a new instinct.

Having attained this position, it became important to apply the principle to the Moon. For some time, the experiment failed, because although the prism afforded a beautifully clear spectrum of the Moon at full, (when placed between that body and the eye) the refracted light was so inefficient, that it became almost imperceptible, when it was reflected from any object unless it had the qualities of a mirror; and as the needles had been acted upon by the solar spectrum, when they were exposed to the magnetic rays on a table, it seemed almost impracticable to adopt the same method, and to discover a suitable mode of operating with the lunar spectrum, unless the prismatic action was made to bear upon the needle, when it *was floating upon water.*

When the experiment was first made, the Moon was nearly full, and the Sun had been for some time below the horizon; but on a subsequent occasion, it was repeated an hour before sunset, four days before full Moon, with great care and accuracy; and as the interposition of glass had no effect upon the magnetising action of the solar spectrum, the author was enabled to make his observations in a well-closed room, and to prevent any currents of air from acting upon the surface of the water, or from moving the needle. It is evident that if the hypothesis about the existence of a powerful magnetic influence in the Moon-beam was well-founded,—the presence of daylight ought not to interfere with the lunar magnetism, provided the visible surface of the Moon be sufficiently extensive.

A common tea-saucer was filled with water, and the needle was made to float on it: the usual self-adjustment of *the point* towards the north magnetic pole took place. The saucer was then placed on a table between the observer and the Moon: the prism was held in such a position, that the unbroken image of the Moon was *reflected* to the eye from the *inner* surface of the side of the prism, and so brought to bear upon the needle, that this *unrefracted* image was immediately over the needle; the floating needle itself was therefore under the intermediate side of the prism which was parallel to the surface of the water, and almost in contact with it. Some such guide was necessary, because the water did not reflect the lunar spectrum during the day, and it was very indistinct even at night. In order to prove that the prism itself possessed no disturbing influence, it had been previously brought close to the needle in various ways, without occasioning the least change in its position.

The following observations were then made:—

1. The needle, with its point towards the north magnetic pole, almost immediately exhibited the effects of the lunar influence. At first, *its point deflected from the magnetic pole to the true north pole of the Earth.* Then the whole needle began to move *laterally*, but slowly, *towards the blue rays of the spectrum*; and after this, its point gradually turned towards the east. When it had placed itself at right angles to the true meridian of the Earth, *or was parallel to the Earth's equator*, it suddenly acquired a new and contrary impulse, and a comparatively rapid

darting motion from east to west, *in the direction of its length*; its head took the lead, but soon turned towards the north. This produced a new compound curvilinear bodily movement of the whole needle, which at last brought its head round to the true north pole of the Earth, where it remained stationary for a short time, if the prism was held in the same position.

2. When the prism was continuously held in the same position, the needle soon began to move laterally as before, and the head then turned towards the east: but although it went through the same varied and peculiar orbitual rotation, the motion was much slower than before: it was stationary for a moment when parallel to the Earth's equator, which was not the case when its point was in that position, and the darting motion which followed was less rapid; but it seemed to undergo the same extent of bodily movement, as to distance, before its poles regained their subsequent parallelism to the poles of the Earth. When, however, it arrived at that position, and its *point* was the north pole of the needle, *there was no pause, as was the case when its head was so placed;* for the needle began immediately to move bodily towards the blue rays of the spectrum.

3. When, however, the prism was removed, (as soon as the *head* of the needle pointed to the north pole of the Earth and became stationary) and was almost immediately afterwards replaced, the rotation was reversed, and the head of the needle moved *towards the west.*

4. Finally, when the prism was removed permanently, the needle soon arranged itself in the magnetic meridian, with that end pointing towards the north, which was there when the prismatic influence ceased; but the change of the poles was not permanent, as had been found to be the case when the needle was acted upon by the direct influence of the Sun; for *its point* gradually came round

to the north, if *its head* had been left in that position, when the prism was removed.

These very interesting observations not only confirmed the hypothesis, that the reflected or *indirect* magnetic energy was far more powerful than that which was promoted *directly* by the inductive reciprocity between *two* heavenly bodies, but they explained the *rationale* of the phenomena already noticed, as regards the magnetic influence of the solar spectrum. They also demonstrated, incontestably, that the colour of a ray has nothing to do with its heating quality, although heat and redness of colour are coincidences, when the solar beam is analyzed by the prism; because the colours of the lunar spectrum are quite as distinct as those of the refracted solar beam. If the faintness of the Moon's light renders it difficult to appreciate the distinction between these colours, when it is reflected from any terrestrial object, we thereby gain the advantage of being enabled to look at her through the prism, without any eye-guard of stained glass, which would interfere with the vivid clearness of her colours.

Upon examining her refracted rays, by bringing the prism between her image and the eye, with nearly the same inclination as when it was thrown upon the needle, her clearly-defined and brilliantly-coloured spectrum exhibited *the blue rays nearest the horizon.* Consequently, as the Moon was to the east of the meridian, these most intensely magnetic rays were to the east of the needle; but supposing she had passed the meridian at the time of observation, the most refrangible rays would have been to the west.

We have just seen that when the head of the needle corresponded with the north pole of the earth, and the continuousness of the lunar influence was broken by removing the prism for a few moments, the renewal of its force induced a rotation in the opposite direction. The head turned to the west.

But it would be a hasty conclusion to suppose, that this phenomenon was due to a gravitating attraction or repulsion, acting between the Moon as a body, and the needle. The facts of the pause in its rotation occurring when it was parallel to the Earth's true meridian,—of its first changing a *lateral* movement of its entire body for one of a *deflection* of its point or head,—and of its next exchanging that for a *darting* movement in an equatorial direction *from* the east, where the Moon then was, as soon as it was parallel to the Earth's equator,—all demonstrate, that the lunar force was really magnetic or controlling, and that the relations which were changed must have been those which previously existed between the Earth and the needle. In order to understand this process, we must examine the whole bearing of our previous magnetic doctrines upon it.

It has been shown that,—as in every ball or shell of unmagnetised iron, there exists a plane of no attraction, or one in which the ball exercises no influence on the magnetic needle,—we are justified in assuming, that *there is one great circle of the circumference of the Earth, upon which there would be no variation of the compass:* because the *dominant* magnetic influence of this globe is that of an *internal* nucleus or ball, which is wholly distinct from its external shell; and where its plane of no attraction existed, the *external shell* would be free to act as the *prevailing magnet*, upon the needle. It has been also noticed, that such is really the case, due allowances being made for the irregularities occasioned by high lands in Asia, which interfere with the uniformity of the great circle in question.

One of the results of the action of the lunar spectrum upon a floating needle, is to *generalize this speciality*, and to annihilate the *dominant* influence of the internal nucleus of our Earth on *any part* of its surface, while that of the external shell becomes the substitute : for when the needle pauses in its rotation, as soon as its head corresponds with the true north pole of the Earth, the *minor* terrestrial influence is dominant, and for the moment there is not even the semblance of any lunar attraction.

Again, after the needle has been so deflected under the lunar spectrum, that it is, at last, parallel to the terrestrial equator,—we may infer from the phenomena of its subsequent *darting* motion, that the interpolar or so-called magnetic terrestrial forces of *both the internal* ball and of the *external* shell, *are neutralised,* and that the needle is only amenable to the galvanic circulating currents which generate them, and which move it in their own direction, away from the lunar spectrum. But as soon as either end of the needle is beyond the influence of the spectrum, in consequence of this movement, the dominant terrestrial magnetic force resumes its empire over the part thus set free, and causes it to deflect again ; which will account in part for the irregularity of its apparent rotation.

When this renewed terrestrial magnetism begins to operate, the bulk of the needle is still under the influence of the Moon ; and the needle, *as a body,* is still independent of the terrestrial magnetic influence, which only acts *on the end* in question, when that small portion of the whole needle is propelled beyond the spectrum. But the end so acted upon is soon brought back under the refracted rays of the Moon ; and the *dominant* terrestrial influence of the *internal* nucleus of the earth is again replaced by that of the external shell ; eventually, even that minor terrestrial magnetic force again disappears under the neutralising power of the Moon's refracted beam ; and the more simple galvanic currents again cause the end of the needle to deflect, until the whole body is again parallel with them.

This explanation of the causes of the needle's rotation, and of the unexpected irregularities of its motion, harmonises perfectly with the facts,—that when the dominant or *major* terrestrial influence is exchanged for the *minor* influence of the earth's external shell, the whole body is under that part of the prism which refracts the red or yellow rays,—and that when the *minor magnetic* currents of the Earth are replaced by the *galvanic* currents, the needle is under the spell of the *more intensely magnetic blue or violet portion of the lunar spectrum.*

As the first result of the prism being brought to bear upon the needle, is a deflection of its point from the magnetic pole to the true north pole of the Earth—and the next effect is a slow lateral movement of the whole needle, —we find in these phenomena, a most satisfactory corroboration of the hypothesis, that *the substitution of the lower for the higher influences of the Earth* upon the needle, *is proportioned to the increase of the lunar magnetic influence*— the *duration* of the impulse being taken into account.

At first, after the influence has prevailed during a certain time, the force, which usually acts on the mariner's compass, gives way to that which prevails on the great circle of "no variation." Then, the magnetising force of the external shell gradually yields to the simpler galvanic force, which force begins by acting upon the whole needle, before its polarity is destroyed,—proceeds to overpower that polarity by deflecting its point from the true north, swinging the needle round bodily, until it is parallel with the terrestrial equator,—and ends by carrying it along in the direction of the galvanic currents themselves, (in which, however, it resists the lunar influence), after its polarity has undergone a temporary annihilation. But, as we have seen, this movement brings one end of the needle beyond the verge of the lunar spectrum, when the *major* or *dominant* terrestrial magnetic currents regain their lost power over that end, until they force it back into the area occupied by the spectrum.

Should this explanation of the whole phenomenon be correct, it would be very inconsistent to attribute any *gravitating* force to the energy of the lunar beam. The influence thus developed is altogether one of *control:* and it acts by inspiring atomic matter with the quality of *withstanding* certain terrestrial influences, in which a subordinate sort of magnetism itself is prevalent.

We have already had occasion to remark that terrestrial magnetism is less powerful, when the Sun is most influential, either as regards his *daily* passage over the meridian, or during the *annual* climax of his summer heat. It is not the least unexpected discovery resulting from this analysis of the above-detailed observations upon the lunar spectrum,—that it manifests a principle of *contrariety,* of a most peculiar character. By as much as the astronomical inductive magnetic influence is purified from heating and gravitating influences, by so much is the atomic body with which it sympathises, liberated by the operation from physical appetencies or regulations, even as regards terrestrial magnetism itself. The needle does not completely lose its *minor* polarity, until it has been moved into the area of the spectrum, which is occupied by the blue or violet rays,—although, through the aid of the red or yellow lunar rays, it has been previously liberated from its obedience to the law, which, under other circumstances, forces it to arrange itself in the magnetic meridian of that part of the Earth's surface, on which it may be placed.

As this process of liberation from terrestrial influences, in consequence of a highly refined astronomical induction, may be supposed to extend to the neutralisation of all terrestrial forces, it is not difficult to speculate upon the probable advent of a period,—when the existing chemical laws of elective affinity will be inoperative, and when the galvanic currents themselves will be as powerless under rays reflected by the more condensed Moon from the more consolidated surface of the Sun, as the terrestrial magnetic currents are *now* in regard to floating needles, when they are exposed to the influences of the refracted lunar beam. If we apply this method of reasoning to phrenological hypotheses, a host of surmises about the freedom of the mental faculties, offer themselves to our imagination: and we begin to understand *why nervous animal* matter, under certain circumstances, may even now develope qualities which are independent of some terrestrially-promoted check or limitation connected with the *lower physical* tendencies of the material world.

Our present object is to discover, why one of the peculiar features of the prismatic *lunar* experiment was the sluggishness of the movement when the *head* of the needle was its north pole, which is connected with *pauses* in its motion; for there were no such pauses when its point, or thinner end was in that position. This remarkable irregularity requires an explanation.

According to our general hypothesis, all the virtues of a magnet are supposed to be due to *interpolar* superficial currents, which are generated by two sets of *circulating* galvanic currents, the one set agitating the ether in one direction, the other in that which is opposite. It seems also, that the pole of an atomic aggregate is the spot at which the interpolar currents *converge*, and that therefore each end of a needle is not the seat of *inherent* force, but the locality of the concentration of currents, which begin to be developed close to the opposite pole: hence it is evident, that the *north* pole of the Earth derives all its magnetic qualities from the interpolar currents, which begin near the *south* pole, and increase in quantity, or in intensity, as they advance *northerly*. The same reasoning is applicable to the south pole, which is the locality where currents proceeding *from* the north would converge: and this is demonstrated by the observations of both Hansteen and Dalton upon the influence of the currents of the *aurora borealis*, when they are visibly propagated in that direction, and affect the *south* pole of the dipping needle.

Now, applying this doctrine to the phenomenon at present under consideration, we find that the magnetic currents *converging at the point* of the floating needle, must have a different intensity from that of the opposite set, which *converge at its head*; because the surface of the needle is more extensive at the head than at the point. As the parent galvanic force circulates round a larger bulk on one-half of the needle than on the other,—that portion must be the locality in which the *contingent magnetic or interpolar currents* must be developed in their greatest quantity. The direction of these currents would be consequently *towards the point* of the needle. *Per contra*, the weaker galvanic currents near the point would generate weaker interpolar or longitudinal currents which converge at the head of the needle. Independently of this consideration, it is probable that the magnetic currents derive additional energy from being near each other before they converge, so that those magnetic currents tending to the needle's point, which are created by galvanic currents between the centre of the needle and its head, act more powerfully at its *point*, than the currents generated at the thinner end would act at the *head* of the needle. Hence we may conjecture, that *the condensation of the needle's greatest magnetic force, takes place at its point.*

We have seen, that the moon's rays in the spectrum neutralise the strongest terrestrial magnetic influence, before they destroy those that are weaker. The relations between the needle and the magnetic meridian disappear first, and those between it and the true meridian of the Earth cease, when the needle is brought into the blue or violet part of the lunar spectrum. The phenomenon suggests, that there is a *contrariety* in this, as in other instances; because the *weaker* lunar influence (its red or yellow rays) annihilates the *stronger* or dominant terrestrial influence over the needle. In reality, however, the Moon does not act upon the terrestrial influence, but only upon the special quality in the needle which sympathises with that influence—a most important distinction, since it reduces the problem to a calculation of the galvanic and magnetic qualities of the needle only, as regards the pause in the movement of deflection, which occurs when its *head* coincides with the north pole of the Earth. There can be no *specific* difference in the nature of the magnetic currents converging at the two ends of the needle: although where these currents are most intense, the galvanic currents are least powerful, and *vice versâ.*

It is therefore explicable, that, as the highest order of currents in the needle are those which are most easily neutralised by the lunar spectrum, while the lower galvanic currents are not affected by it,—the needle's *head*, (where the galvanic currents are most powerful, and the magnetic currents are the least so), *should pause in its deflection.*

But we must guard ourselves against the supposition, that the *magnetic* terrestrial influence is *physically* stronger, as a force of attraction, than the *galvanic* force which generates it, and which is not annihilated by the existing power of the Moon. According to our general theory, the strongest of all attracting influences is that early species of the gravitating force which makes atoms cohere; and we have already inferred, that the intensity of the *gravitating* force diminishes as the *virtue* of the magnetic currents increases. We have indeed speculated upon such a possibility, as the *eventual* superiority of astronomically-produced magnetism being able to abrogate all the laws of chemical affinities, which can only be enforced through the instrumentality of *cohesive gravitation.* But there is a decided difference between the more refined processes of terrestrial magnetism and the lower and less complicated relations between atoms and particles of atoms, where the magnetic reciprocity is of a much more simple character. At present, however, it is sufficient to assert, that in such relations *between bodies* as those in which a higher inductive power prevails over physical gravitation, the astronomically-derived force is able to inspire bodies with a capability of withstanding the influence of terrestrially-produced magnetism.

Still the phenomena of *organic* chemistry, even in the present state of the solar system, may exhibit the effects of an astronomically-occasioned interference with the more elementary tendencies which prevail in the *inorganic* chemical scheme of Nature—as will be shown hereafter when the *physiological* influence of the moonbeam is the object of our remarks.

Having before us a complete system of terrestrial magnetism, we find no difficulty in accounting for every peculiarity of the phenomena observed when the floating needle is submitted to the action of the solar and lunar spectra.

If we apply our method of accounting for the locomotion of the needle under such conditions, to the solution of the problem, we discover :

1. That when the refracted rays of the Moon are brought to bear upon the point of the needle, its dominant relations of magnetic reciprocity to the chief terrestrial magnet are disturbed, and it falls under the empire of the *minor* magnetic influence, which obliges it to turn to the true north, or to that locality outside the earth's atmosphere, to which the external interpolar currents that agitate the

ethereal envelope of this globe, converge in the northern hemisphere.

2. When the lunar influence increases, the magnetic currents of the needle are entirely neutralised on that side nearest the most powerful spectral rays, but not so completely on its other side. Its equilibrium is therefore destroyed, but its polarity still exists during the lateral movement of the whole body. By degrees, however, *the simpler galvanic force* of the Earth, which generates all terrestrial magnetic currents, and *which has its own temporary power of attraction, acts upon that side of the north end of the needle on which the lunar influence has neutralised the needle's own interpolar currents which reciprocate with those of the Earth,* and causes it to deflect towards the equator; this process at last brings the whole needle parallel to those galvanic currents which agitate the extreme ethereal envelope of the earth circularly, and at right angles to its poles. When the Moon is to the east of the meridian, the needle is hurried on by sympathising with these currents which go round the Earth from east to west, until, when its head is beyond the spectral influence, its own magnetic currents are liberated in that portion of the whole body which has been projected beyond the refracted rays of the Moon.

3. When, however, the *head* of the needle is its north pole (the lunar influence being maintained as an increasing force), the pause in its motion implies, that as the magnetism of that end is weaker than that of the other, the neutralising effect of the Moon's spectrum is less powerful there; the whole phenomena teaching, that the neutralising power of the Moon is stronger in proportion to the quantity of the *interpolar* currents which it annihilates. A more intense magnetic action of her rays is requisite to destroy the sympathy between the *minor* terrestrial currents and those of the needle, than is capable of breaking

the connexion between the needle and the dominant or *major* magnetic meridian of the earth.

On the other hand, the fact,—that if the prism be removed for a few moments (when the head of the needle is its north pole), and be afterwards again placed over it, the renewed motion of the head of the needle is a deflection to the west, or to the side of the meridian opposite that occupied at that time by the Moon,—demonstrates, that if there be no continued impulse of her neutralising influence, she acts *anew* upon the point of the needle in preference to its head, and induces the whole body to move into the parallel of the galvanic current, by suspending its magnetic currents *on the side of the south pole of the needle,* which is still the side nearest the most intensely magnetic rays of her spectrum.

When this explanation of the lunar phenomena is applied to the more simple effect of the solar spectrum upon the needle (involving a mere change of its poles), we may surmise, that such a change is occasioned by the solar magnetic rays having neutralised the needle's *major* magnetic currents at its point, in consequence of which, its *minor* magnetic properties induce it to adjust itself, with *its head*, instead of its point, towards the magnetic pole of the Earth. But we must infer, that the Sun's refracted spectrum cannot destroy the relation between the whole needle and the terrestrial *magnetic meridian*,—which operation is the commencement of the process, when the needle is submitted to the more powerful influence of the lunar spectrum. Still there is a *permanency in the effect of the solar spectrum* upon the needle; for after an interval of twenty-four hours, it had not regained its tendency to adjust itself with its point towards the north; but this quality soon returned after it had been made to undergo all the interesting changes of position, which were induced by its exposure to the lunar spectrum.

The general conclusions suggested by the observations in both instances are as follows:

1st. When the magnetic rays of the Sun are refracted by a prism, whether they proceed *directly* from his surface, or *indirectly* from that of the Moon by being reflected through a non-atomic medium, they interfere with those subordinate magnetic phenomena of reciprocal sympathy, which are developed by the ordinary influence of one terrestrial aggregate of atoms upon another.

2ndly. The solar spectrum has only a power of suspending the *highest* magnetic reciprocities of subordinate terrestrial bodies, during a certain period.

3dly. The lunar spectrum is adequate to the promotion of much more important changes in the magnetic qualities of subordinate terrestrial bodies, and of suspending or abrogating all their affections, in relation to the *minor* as well as the *dominant* interpolar currents of this planet: but such changes are dependent upon the continued presence of the refracted rays of the Moon, which is not the case when they are occasioned by the solar spectrum.

4thly. This difference between the durability of the solar and lunar influence, is probably connected with the fact—that the *heating* and *gravitating* forces of the solar rays are accompaniments of his *direct magnetic* rays; and that he not only acts upon terrestrial bodies through their joint agency, but at the same time induces changes in the qualities of their molecular constituents; while his rays *indirectly* reflected upon such bodies from the Moon's surface, only act upon the terrestrially promoted *magnetic* qualities of the envelopes of their constituent corpuscules, or particles, without inducing them to expand;—such induced expansion being the *real cause of the heat* which they appear to derive from an exposure to the Sun's rays.

5thly. On the other hand, the changes induced by the *indirect* solar magnetic rays, when reflected by the moon, may be more extensive as regards the promotion of new combinations of the particles, corpuscules, and other constituent parts of terrestrial bodies, notwithstanding the absence of those heating and gravitating inductive powers which belong to the sun-beam. The above experiments demonstrate beyond a doubt, that the lunar spectrum can impart new appetencies to inorganic bodies, by suspending some of the higher terrestrial influences which are themselves magnetic; and it is most probable that it has a stimulating as well as a neutralising energy, which is capable of evoking the higher organic qualities of terrestrial matter.

6thly. If the highest physical agent of the Divine intention be the magnetic energy, we are justified in assuming that the proximate cause of vital and mental activity in material bodies is this inductive influence:—that when in its mixed character it is promoted *directly* by a reciprocity between *two* heavenly bodies, it occasions such a permanent motive faculty as that of life;—but that when it is isolated, and unmixed with the inductive forces, which occasion heat and attraction, it is the representative of *abstract mind*, and is confined to the task of administering the laws of a higher system of changes. Like that system, of which it is at once the generator and the creature, the magnetic force advances progressively from the simple to the complicated. Its lowest conceivable attribute is the formation of the atom: it then proceeds to enforce and direct the combination of atoms, in accordance with the laws of a most complicated but intelligent plan: it afterwards modifies such combinations with the same harmony, and for the promotion of higher objects.

7thly. When we ponder on the above noticed phenomena, induced by the influence of the solar or lunar spectrum on inorganic matter, we find that this manifestation of a new affection where there is no new substance, embodies the idea of a much higher order of *elective* power than any which is observable in chemical phenomena; because in all chemical changes, some new terrestrial accident in the juxtaposition of different sorts of substances introduces *an evident necessity* for the display of a special elective affinity. The new neighbour may be more or less congenial with one of the particles of the existing corpuscule than those particles are with each other; and there may be a decomposition, or there may not. But in this instance the only new element is the incorporeal influence promoted by astronomical inductions; and its interference is so overpowering, that the *most dominant* of the two great terrestrial magnets is rejected, and the affection of the needle for the *weakest* of the two (speaking physically) is apparent to our eyesight. The result is almost a physiological phenomenon and the display of a sort of *mental* power in the needle, which implies something more like a change of ideas in the mind of a thinking being, than the phenomena of elective affinities in the chemical world.

This experiment is the more satisfactory, as it clearly proves that the influence of one heavenly body upon another does not merely occasion such gravitating results as their respective locomotions, and the tides of their fluid or gaseous surfaces; but that, if we may use the word, it *inspires* portions of such bodies, or subordinate aggregates of atomic matter, *with inclinations* to avail themselves of the gravitating or expanding and contracting forces, and to *make use* of those instruments of power, *in opposition to the ordinary physical laws.*

SECTION XIII.

On the relations of Light to the other inductively *promoted influences of Electricity.*

Before we enter upon the consideration of those phenomena, in which *inductive* electricity appears as the *quasi-intelligent* controller and commander of Nature's mighty system, with attributes which come nearer our idea of a metaphysical or mental influence over physical forces, than that of a physical force itself—we may devote a few pages to the subject of Light. We are led to meditate upon this subject by our previously detailed experiments on the influence of the solar and lunar spectra, in which there is an undoubted coincidence between the illuminating and the magnetic powers of the Sun and Moon, when they interfere with existing reciprocities between the magnetic currents of our globe and those of a floating needle.

In the preceding remarks upon the magnetic influence of the Moon, it has been demonstrated, that the controlling power is greater than that of the Sun, and that the absence of that *heat-producing* inductive energy, which accompanies the *direct* transmission of solar light through the ethereal medium, so far from diminishing the magnetic influence, is coincident with the manifestation of more refined effects, when the solar rays are reflected from the Moon's surface upon the Earth. Hence we may infer, that the rays in the spectrum which produce light, are of a higher order than those concerned in the generation of solar heat. There are also reasons for supposing that other *physiological* effects besides those of an action upon the eye, are occasioned by the influence of the moonbeam, or, in other words, by the reflected solar ray, when after reflection it passes through the ethereal medium, which cannot be understood from any observations upon the solar beam when reflected from a terrestrial body which is within the medium of our atmosphere.

But all our previous conclusions lead to the inference that the production of light is an *inductive* phenomenon under all circumstances, whether it be manifested in consequence of sympathetic relations between portions of the atomic matter which constitute the earth, or between the heavenly bodies. It is not to be attributed to the *radiating* action of currents between the poles of a single "magnet," but to a sympathy between the currents of *two* magnets, in each of which there is the interpolar activity: and this applies to the largest and smallest bodies, to portions of any heavenly body, as well as to separate heavenly bodies.

Between some bodies there may be no light-producing sympathy, because the mutual relations of their constituent molecules may not be such as to develope light. But the interpolar action in both bodies exists constantly, notwithstanding the absence of such phosphorescent qualities. A due appreciation of these reasons why light is not evolved by all bodies, and during all chemical processes, will aid our endeavours to arrive at a clear conception of its nature.

We find that the phenomena of the aurora are explicable on the supposition, that there is an inductive action between the extreme interpolar currents of this globe and *our organs of vision;* and that those of the light of the Sun, Moon, or Stars, are due to a similar process. Objects of sight may be classed under two heads,—those which we see in consequence of the *direct* sympathy between them and our eyes, or nerves of vision, and those which are visible in consequence of the more complicated operation of nature, which we term *reflection*. The Sun, the fixed stars, the aurora, lightning, and all *phosphorescent* terrestrial bodies, are seen in consequence of the direct and immediate sympathy between them and our eyes: the Moon, the planets, and all *non-phosphorescent* visible objects, are presented to our visual perception, because they *reflect* the light which is occasioned by their simultaneously sympathising with another body in the ordinary or direct mode.

Not only must we avoid the error of supposing that there is any transfer of *substance* in the phenomena of vision; but it would be incorrect to imagine, that there is any general radiation of an impulse as from a centre. The operation is one of the higher order of *sympathy*, and the undulatory hypothesis is no less opposed to this idea than the molecular hypothesis is. The solar *heating* rays which cause *individual* terrestrial bodies to expand, and those lunar as well as solar *gravitating* influences, which raise the waters of the ocean and the atmosphere of the earth, as masses, also act sympathetically; but in both instances they induce an activity which resembles simpler developments of force than those of an ordinary magnet. Illumination however belongs to a more elevated order of phenomena than corporeal expansion or any sort of gravitation.

The hypothesis upon which the whole theory set forth in this treatise is based, differs considerably from those of the opticians who advocate the doctrine of *radiating atoms* of light, or of a radiating impulse which produces *concentric undulations* of an essential fluid.

1st. *Our* ether is a fluid homogeneous substance, manifesting no idea of form: *theirs* is composed of atoms, which are supposed to resist the motions, and change the orbits, of such bodies as gaseous comets; therefore they make it a compound of particles developing *ideas of form* throughout universal space.

2ndly. According to our hypothesis, it is a medium capable of being agitated by the *mutual* impulses between atomically composed bodies, which it communicates from one to the other, and may be said to assist in developing: the impulse is communicated in straight lines, but the atomic bodies change their own position in elliptic curves:

and as the rectilinear impulsion depends upon the mutual influences of two such bodies *in every portion* of the line of connexion, there is a development of two opposite forces, crossing each other. Their hypothesis is founded, either upon the idea of a centrifugal radiation of atoms, or upon that of a radiating impulse *created by one body only*, which throws the intervening medium into a state of concentric undulations, like those on the surface of water: according to this notion, there is a waste of all the portions of the wave, or of all the radiating atoms, which do not impinge upon some other body. The importance of this distinction is so great, that it ought never to be lost sight of during the perusal of the whole essay. Both the popular theories of light (the radiating and the undulating) insist upon the postulate, that all matter is atomic, because the hypothesis, which ascribes the phenomena of optics to "waves" and "undulations" like those of sound in atmospheric air, or ripples on the surface of water, is based upon the elasticity of an atomic compound, and suggested by the qualitics of fluid *atomic* matter. On the contrary, our hypothesis supposes, that the impulse is projected in a straight line by jerks or pulsations, without any undulation whatever, and that this manifestation of force, *without locomotion*, is in its most primeval condition as regards matter, when it is propagated between two points in the ethereal medium, which become the poles of an atom. The only analogy to this sort of action, is found in the motion of a single body projected in an apparently straight line, where there is no possible undulation: yet this *locomotion* of atomic matter in space is really the antagonistic or contrary sort of motion to that agitation of the ether, which has no locomotion in its homogeneous character, but only *conveys motive powers* between objects which have locomotive qualities.

It will be found that all the phenomena of light, which indicate the existence of a vibrating medium, may be perfectly explained, and best accounted for, by our hypothesis of a mutual influence of *two* atomic bodies : the phenomena of astronomy tally with the suggestion, and those of inductive electricity are not otherwise explicable.[w]

That light has a powerful *chemical* influence, has been

[w] Most of the *appearances* of motion *within our atmosphere* imply a curvilinear direction, even when the transfer or exchange of electricities between the contiguous bodies is of an inductive character.

The discovery of the *diffraction* of light, which was made by Grimaldi of Bologna, proved that the propagation of the illuminating influence itself cannot be exempted from this deceptive mode of manifestation: and the deeply considered hypothesis of Dr. Faraday, who has found ground for disputing the doctrine of preceding electricians about *inductive direction*, in consequence of experiments, which, to use his own expression, makes the inductive influence " turn a corner," has already had the effect of promoting a new theory, which is likely to lead into error. It breaks down the clear and well-defined distinction between those purely inductive astronomical influences which act rectilinearly between the heavenly bodies through a *non-atomic* medium, and the terrestrial inductive relations between connected portions of the same body, where the action between particle and particle is of a curvilinear character.

When the inductive current of agitating influence passes from one particle to another, (supposing the two particles to be in contact) not only would it follow the surfaces of their constituent atoms, but if it continues its course to a third particle, the *general* direction of the impulse may diverge from a straight line in consequence of some law regulating its course amongst particles, corpuscules, or terrestrial bodies, which are all conductively related through the medium of atomic matter. Now, as it is only the *general direction* which can be observed by the practical electrician, he might infer from his most delicate experiments, that the inductive ray itself would " turn a corner," while in reality the deviation from a straight line does not occur in an unbroken ray, but in a simultaneously visible repetition or continuation of distinct rays, whose number may exceed several thousands ; and the general line of propagation of the influence from one particle to another, may be governed in all cases by laws enforcing a general direction like those which are apparent, when the magnet acts upon iron filings. Be this as it may, we know that the magnet compels both a curvilinear locomotion and a curvilinear arrangement of such distinct bodies.

The facts discovered by Grimaldi and Dr. Faraday cannot be contested ; but they do not justify the abandonment of the previously prevailing theory that *unbroken* inductive rays, or agitations of the ether, are rectilinear in all cases; while on the other hand, they afford additional testimony in favour of the assumption that all material locomotion occurs in elliptical curves, even as regards the phenomena of chemical decomposition, and the action of elective affinities upon particles of such excessive minuteness, that no microscope can detect their individuality.

long since admitted, and many modern natural philosophers have termed the rays at the blue or violet end of the spectrum "chemical rays." Now as chemical composition and decomposition are always connected with the *physical administration* of those omnipotent laws which give to molecules an apparent instinct of obedience, when elective affinities and chemical equivalents are in the contemplation of the *magnetic impersonal choice*, we arrive at the conclusion, that it is not the illuminating, but the magnetic or sympathetic rays of the Sun which induce this appetency in terrestrial atoms to change their relations to each other, in accordance with such laws. This notion is supported by the experiments which show that the chemical changes in the colours of bodies are more rapid and energetic under the influence of the violet rays and the dark space beyond, than of the blue,—and under that of the blue than of the yellow, or red: it follows as a just conclusion, that it is not light or the illuminating influence, but an energy of another character which really occasions the chemical changes in question, because where light is most vivid, there is less of that influence than where there is very little or no light.

Experiments in organic chemistry of a very interesting nature have been made by Mr. Hunt, by which he has shown, that seeds exposed to the action of *blue* and *violet* rays germinate with extraordinary rapidity, and that on the contrary, when they are exposed to the red rays, their germinating properties are destroyed; while the yellow or most luminous rays, although they do not kill them, diminish their vital energies.

One of the most important deductions from our general theory with respect to the secular change of form of the ultimate atom, is that the light-producing quality of bodies holds a relation to the degree of the oblateness of some their constituent atoms,—and that during the whole period of the change, although their magnetic qualities continue to increase until their dissolution, they are unable to affect our organs of vision long before they cease to develope the magnetic force. The same observation applies to their inductive heat-producing influence: there is an invisible point beyond the red or least refrangible rays of the solar spectrum which (in most instances of prismatic experiment) so acts upon terrestrial matter as to elicit greater heat, than is found in the *visible* red and yellow rays.

Hence it would appear, that notwithstanding the seeming homogeneousness of the solar beam, and the blending together of its heating, illuminating, and chemical rays, when the prismatic analysis is not resorted to—heat is discovered by that mode of analysis to be most intense, where light has not yet been produced, while the highest chemical (magnetic) influence does not develope itself until the illuminating quality ceases to be in activity. This conclusion suggests, in relation to the influence of the refracted Moon-beam, that a far more powerful *inductive influence* than that demonstrated by our experiments on the visible lunar spectrum, may prevail where it is reflected, but where the atomic conditions of a heavenly body holding an analogy to our Sun are such as to have passed through that stage of oblateness, beyond which there is no capability of producing light. It is indeed very probable, that some of the most refrangible rays of the Sun which do not affect our powers of vision, are reflected by the Moon, and are mainly concerned in those extraordinary physiological results of her influence when she is nearly full, which will be hereafter brought under the notice of the reader.

The observations of Newton upon the refrangibility of the differently coloured rays of the solar spectrum, demonstrate that there is a greater rapidity of impulse where the refrangibility is greater.[x]

[x] Sir John Herschell, in publishing the following table in support of the undulatory theory of light which may be applied with advantage to the hypothesis advanced in the present treatise,—says, in reference to the extreme delicacy of observation which was requisite to its construction, " That man should be able to measure with certainty such minute portions of space and time, is not a little wonderful; for it may be observed, whatever theory of light we adopt, these periods and these spaces have a *real existence*, being in fact deduced by Newton from direct measurements, and involving nothing hypothetical but the names here given them."

Colours of the Spectrum.	Lengths of an Undulation in parts of an Inch.	Number of Undulations in an Inch.	Number of Undulations in a Second.
Extreme red	0.0000266	37640	458.000000.000000
Red	0.0000256	39180	477.000000.000000
Intermediate	0.0000246	40720	495.000000.000000
Orange	0.0000240	41610	506.000000.000000
Intermediate	0.0000235	42510	517.000000.000000
Yellow	0.0000227	44000	535.000000.000000
Intermediate	0.0000219	45600	555.000000.000000
Green	0.0000211	47460	577.000000.000000
Intermediate	0.0000203	49320	600.000000.000000
Blue	0.0000196	51110	622.000000.000000
Intermediate	0.0000189	52910	644.000000.000000
Indigo	0.0000185	54070	658.000000.000000
Intermediate	0.0000181	55240	672.000000.000000
Violet	0.0000174	57490	699.000000.000000
Extreme violet	0.0000167	59750	727.000000.000000

The most beautiful and delicate analysis and observations of the refracted beam, are those of the foregoing table, which have determined the length and number of undulations, or (as they should be termed in accordance with our hypothesis) *jerks* or *throbs* of each sort of ray, which to an eye capable of such minute discrimination, ought to be perceptible within an inch in space at the same moment, or which would strike on, or pass by, the same point, during a second of time. The yellow ray does not maintain a middle position, in the table which indicates the differences between the rapidities of the motion of the rays. If we examine this table, we find that 37,640 undulations of the extreme red ray appear at once in the same inch; and that 458 billions of its so-called waves pass into or out of this region in a second of time. The extreme violet ray at the other end of the spectrum, exhibits a rapidity which gives 59,750 separate waves (or points of impulse) at the same time, within the inch, while 727 billions of them take place at the same point, during a second of time.

Now, the mean number of the two extremes in this scale, as regards the division of the inch, is 48,695; and as regards the succession of the impulsions at the same point, it is 592½ billions per second of time. This tallies nearly with the numbers attributed to the intermediate green ray, or the part of the spectrum which is between the

In the subjoined table we find a gradual increase in the rapidity of the vibrations; the extreme luminous red rays being to the extreme violet rays, as about 4 to 6 in their rate of impulsion.

The ethereally-conveyed sunbeam is undoubtedly the manifestation of a compound, but general impulse; but

green and the blue rays—where 49,320 is the indicator of the quantity of undulations at the same time within the space of an inch,—and 600 billions is that of the number of impulsions at the same point, in a second of time. But 49,320 is flanked in the table by 47,460 on one side, and by 51,110 on the other; 48,695 is therefore a sufficiently accurate approximation to 49,320, for our purpose; while 592½ is nearer 600, than 600 is to 577 or 622, which are the numbers of billions affecting the rapidity of the adjoining rays in the table, on either side of the intermediate ray in question.

The method of dividing the spectrum into two parts, according to the mean rapidity of the motion of all its rays, places that mean in such a position, that the prevalence of the blue rays is on one side; while that of the red and yellow rays is on the other. When we search for the subordinate mean between this intermediate ray and the extreme red ray, we find that it nearly coincides with the numbers attributed to the yellow ray. The subordinate mean between 37,640 (the spacial number of the extreme red ray), and 48,695 (the general mean already discovered) is 43,267½: this corresponds with 525¼ billions of impulsions at the same point, per second. The number of the yellow ray in the table, is 44,000; which cypher is flanked by 42,510 and 45,600—neither of them approximating so nearly, as 43,267 does to 44,000; while 525¼ is nearer 535, the number of billions of impulsions of the yellow ray, than its neighbours in the table (517 and 555) are to the same 535.

Thus we find, that the *motion* which seems to be intimately connected with the creation of the general phenomena of the solar beam, is capable of being itself the analysing measurer of the leading conditions of the problem. The different shades of the blue ray occupy as large a portion of the scale of varieties of rapidity, as that which is conjointly attributed to the different shades of the red and yellow rays—the bisection in this particular being near the green ray, midway between the brightest blue and yellow points in the spectrum. But the brightest yellow occupies a mean between the intermediate green and extreme red rays; so that according to this method of appropriation of the general difference in time between the rapidities of the extreme visible rays of the whole spectrum, one-half of the whole time is attributed to blue and shades of blue—and one-quarter (or one-half of the remainder) to the space between the green ray and the centre of the yellow ray; leaving only one-quarter for the red rays, and for those of an orange colour which are on the red side of the yellow. Pursuing this investigation, and finding the mean of this quarter, (which gives 40,820 as the divisions of the inch, and 496½ billions as the number of pulsations in a second), we discover that the spacial number of the in-our senses only inform us of the existence of *one* of its *producing causes*, namely, the Sun, which *seems* to be the *radiating* generator of both light and heat; while optical phenomena do not suggest the doctrine, that this uniform action (where varieties of rapidity constitute the only apparent causes of difference in the coloured rays), is to be attributed to a progressive series of impulses, which depend *ultimately* upon the joint influence of the countless millions of atoms in the celestial body. Indeed this joint influence is blended in one general impulse, when it produces the current of the aurora, between the poles of the Earth, or (as we believe, when reasoning by analogy) between those of the Sun; we may therefore consider the entire body of the Sun as if it were a single atom, in so far as the compound and uniform phenomenon of its beam is concerned; but as if it were a congeries of separate atoms, in all that relates to the variations of rapidity in

termediate ray between the orange and the red, is 40,720, while that of the pulsations in a second of time, is 495 billions, a nearer approximation than any we have yet attained. Thus the red rays, and those which are intermediate between it and the orange, only vary in rapidity by one-eighth part of the whole variation developed in the general scale of the spectrum. The variation between the purest yellow ray and this intermediate point, equals another eighth.

Hence the apportionment of the whole variation of rapidity, supposing it to be divided into eight parts, will be as follows:—

Blue and shades of blue, bounded by the intermediate green ray, 4 parts.

The interval between the yellow and intermediate green rays, 2 parts.

The interval between the yellow ray and the intermediate ray which is between red and orange, 1 part.

Red, bounded by the intermediate ray between its own shades and the orange or the remaining interval of the visible spectrum, 1 part.

These divisions are all, however, at points of the spectrum, which belong to the different species of its phenomena. The first point is on a *neutral* colour, which is the indicator of a prevalence of the blue over the yellow. The second is on the supposed brightest point in the spectrum; and this is the apex of the yellow ray. The third is at an intermediate point, not between the red and yellow, but between the red and neutral colour, orange, which point corresponds with that which is placed between the green and yellow. We have seen that the intermediate green ray itself is the bisector of the whole extent of the variation, which is as 3,764 to 5,975, or something more than the difference between 4 and 6.

its rays, and the consequent differences between their heating, illuminating, and magnetic properties. When considered in this manner, the atomic doctrine suggests the following explanation of why there are different coloured rays and properties in the sunbeam.

If each molecule in its complication with other molecules which constitute a body, contributes its influence to a general galvanic impulse, occasioning those interpolar currents which promote the inductive beam, its *special* power need not be altogether lost; but it may be blended in a ray with that of others, all apparently promoting one and the same colour. And this process must be of a complicated character, because the superficial or interpolar action of the heavenly body, *seems* to confound *all* inductive individual impulses, when they are again developed by the ethereal inductive pulsations which take place in a new direction, as straight lines, between two bodies, and are not analysed by the prism, or some other refracting medium.

Now when the general phenomenon is explained by referring to the *aboriginal* force, we may suppose, that the interval between the throbs of separate atoms, would be shorter in relation to the diminished distance between the poles of each molecule, or to its secularly increasing oblateness. The motion manifested in the blue rays at one end of the spectrum, is more rapid than that of the red rays at the other; while decrease and increase in rapidity, (as regards the succession of the agitating influences) may coincide with the expansion and contraction of the bulk of each atom; and it is in perfect accordance with this notion, that the heating rays of the spectrum should hold a relation to those atoms of a terrestrial body, each of which, it may be inferred, is less oblate than those which develope the most intense illuminating activity. This mode of reasoning offers a new and important suggestion about the *primary* action in each atom. We may suppose that it is developed in jerks or pulsations: we may measure the intervals between the pulsations: *and it is possible that we may thereby inferentially determine the size of the atom itself.* It seems probable, that not only is the size of the atom concerned in the measurement of the interval between the throbs, but that the existence of a system of pulsations in *the original impulse* which maintains the atomic being, is thereby indicated. Such notions are the legitimate offspring of inductive reasoning; and if the existence of the atom depends on the pressure of an expanding force, it becomes an interesting problem, to ascertain how such a force may act. Two modes are possible; the one by jerks, —the other, in a smooth and continuously sustained motion: the analogy is in favour of the system of pulsations, and of *alternations of motion and rest, even in this first comprehensible manifestation of material activity.*

The relation of light, both to heat and magnetism, may also be further elucidated by the scale of rapidities in the different rays of the solar spectrum: we have already suggested, that as *there are dark heating and dark magnetic rays*, it is a justifiable inference, that so far as this sort of inductive *light* is concerned, its manifestation *belongs to some interval in time*, *shorter than that allotted to the existence of the constituent atoms in bodies between which it is promoted.* Supposing that there be a *constant secular* change in the atomic bulk,—an increase of the primary rapidity of the interpolar agitation in each atom, may be a condition necessary to the development of light or of the phosphorescent state of an atomic body. Again, there is a limit to this luminous development, which ceases before the atom has been contracted to its *minimum;* and if the analogy to the rays of the solar spectrum holds good, there can be no light, when there are more than 60,000 breaks or pulsations of a ray within an inch at the same time.

Now let us apply these important inferences to astronomical phenomena, before we consider the calculations on this point in detail.

In the solar system there is but one body which appears to be wholly phosphorescent. The sun alone has that quality to such an extent as to illumine other bodies in his system. But we are aware of the existence of myriads of other Suns, each shining with his own light: and the above surmise may enable us to explain the interesting fact of those differently coloured stars appearing in the heavens, which ought to produce spectra having different proportions of the *heating* and *magnetising* rays (if they were capable of measurement, which they are not, in consequence of their distance), because there is a variety in their degrees of atomic condensation. A star beginning to be luminous, would, according to this hypothesis, display a predominance of *red* in its light: and one which had reached the limit of its phosphorescent state would appear *violet*. Our own Sun's white light would imply, that his phosphorescent condition is that of a body which has attained a climax as regards light.

That there are dark bodies in the Heavens, not merely as planets, but as centres of systems, is most probable: and it is not difficult to speculate upon astronomical conditions which tally with all the phenomena that we observe, and which suggest the likelihood, that others, never yet observed, are occurring here and there in the great ethereal medium of all atomic existence. Some stars have been known to shine out with surprising brightness, and then to disappear totally. New stars have also appeared suddenly and remained permanently visible: others have disappeared from the heavens although they are enumerated in catalogues. May not these wonders be accounted for by a *comparative* violence in the rapidity of changes far more general in their influence but yet resembling those of chemistry upon our globe? The change of bulk in a comet affords ocular demonstration, that great alterations may be most rapid, and proves that there may be cycles of atomic dilatation and contraction, independently of the slow but constant diminution of the absolute size of every atom in the cometary body.

The hypothesis of Sir D. Brewster supposes that the seven colours of the solar spectrum are produced by the intermixture of blue, yellow, and red rays, which interfere with each other in some points more than in others; that these three primitive colours exist at every point of the spectrum; that, as they constitute white light, the colour at every point of the spectrum may be considered as consisting of the predominating colour at that point, mixed with white light; that where the ray is red, there is so much more of that colour than of the yellow or blue, that they hardly interfere with the red ray; and that the same happens, *mutatis mutandis*, with respect to the yellow and blue rays.

He supposes the intensity of the light to be in the yellow ray; but experiments have shown, that the site of the *maximum of heat* varies in the solar spectrum according to the substance of the prism; when water is used, that maximum is in the yellow ray; in crown or plate glass it is in the middle of the red; and in flint glass it is beyond the red. The analogy, therefore, would suggest, that as regards the *maximum of light*, it is variable according to the medium of the prism. Frauenhofer found it in the orange ray. Future experiments will probably determine the general laws which govern the development of these properties in the solar beam, in relation to the various sorts of refracting *media*.

Experiments prove that if the throbs of two rays of a similar colour, from different prisms, fall upon the same spot *at one and the same moment*, they produce an intensity of that colour on the spot in question; but that if they, or their so-called undulations, succeed each other in such a manner, that they divide the appropriate *intervals* in time between the moments of the impulsions (which intervals are peculiar to each sort of ray) there is *darkness* at the spot so impinged upon. This explanation of the phenomenon is complete, if we admit that there are no undulations, and that the impulse is communicated through the medium of the ether without any locomotion of that medium itself; and we may use the term "intervals of fits of transmission" without adopting the theory of undulation. It is obvious, that if the number of the succession of the *jerks* or *throbs* be greater than 60,000 or less than 35,000 in an inch, they would produce no light; and that if any number between 35 and 60 be doubled, it must exceed 60. But in consequence of the interference of two rays, in any part of the spectrum, the joint number of the fits or strokes upon the spot on which both rays fall, will exceed those of the extreme violet ray, unless the strokes of both the rays be simultaneous. The result would be, that the operation would not produce light; because the succession of impulses would exceed the *maximum* indicated in the table which attributes less than 60,000 intervals in a square inch to the extreme violet ray. The difference, therefore, is considerable: and as motion is so essential a principle in nature, we find no difficulty in reconciling the great contrast between the influences of heat and magnetism with such a variation of rapidity in the same general class of phenomena. All observations confine the intensity of the illuminating influence, to that half of the difference which includes the hottest rays. Light and heat, therefore, may be inferred to hold a nearer relation to each other, than light does to magnetism on this account; the inference that light and magnetism are distinct qualities of the Sun, is supported by other physical evidence.

The general result of these calculations, so far as the position and rank of the brightest rays are interested in them, is, 1st, that solar light or brightness, without reference to its colour, is due to an impulse or agitation of an ethereal medium between two atomically composed bodies. In this respect it offers an analogy to inductive heat and magnetism when developed in the same manner; but we must be careful to avoid confounding the magnetising power of the Sun's rays with the general gravitating influence which he exerts upon other bodies in his system.

2ndly. We find heating and magnetising rays devoid of light, at the extremities of the spectrum; but as we do not discover illuminating rays altogether unaccompanied by heating or magnetising powers, we may infer that *the development of light was not a phenomenon congenital to the atom, and that it did not take place until after that of* heat had been made manifest; in other words, that there was a period when the atoms of the solar system existed in darkness.

This inference is capable of a still wider application: we may conjecture that every molecule has two distinct non-luminous periods of existence—the one while it is advancing to its climacteric form and the sympathetic pulsations between its poles are not sufficiently rapid—the other when it is become very oblate after having passed that climax, and the succession of its pulsations is too rapid for the manifestation of illuminating properties, although the intensity of the magnetising influence is thereby increased.

3rdly. This hypothesis is completely in accordance with the notion, that the magnetic and gravitating influences of nature are produced by different forces in the original atom, although they are so combined in the magnet, that the most obvious phenomena have suggested that they are identical: but the critical analysis of such phenomena explains, that the magnetic influence in that instance *guides* and *controls* the gravitating or attractive power, as it does in any case of elective chemical affinity. The gravitating power attached to the atom during the whole period of its existence is an *invariable quantity*, if there be any truth in the doctrine of chemical equivalents. The heating and magnetising powers may also be its constant attributes, but as *variable quantities*, both beginning at zero, when the atomic germ is first developed—heat mounting to the highest point, when the expansion is at its maximum, and ending at the lowest point in the thermometric scale, when the atomic contraction is complete—while the magnetising influence does not become highly operative, until the heat is diminished. But the illuminating influence (unlike heat, magnetism and gravitation) does not appear to be a constant attribute of the atom.

Such an explanation accounts for heating and magnetic powers being promoted *in darkness* at either end of the spectrum. It also confirms the analogical presumption, that *as regards the same atoms*, the developments of heat and gravitation are older phenomena than that of light, which can only be manifest when atoms have a certain shape; if they are too oblong, their vibrations may be too slow to cause it: if they are too much flattened, the original ethereal vibration on their surfaces may be too rapid. The analogy between light and sound is very complete: they are both relations to our senses and useful under a particular organisation: but it is easy to imagine a higher sort of material animalisation in which neither hearing nor seeing may be necessary as means of communication between the perceiving animal and the thing perceived.

The presence of light, when refracted by a prism, is accompanied by a polarisation of substances, which have been generally believed to be devoid of all magnetic qualities. A small needle of light wood floating upon water, gradually arranges itself in the magnetic meridian when submitted to the influence of a prism, even if the light of a candle be the origin of the refracted ray. Experiments have been made, which prove that diffused daylight, when the Sun is covered by clouds, or so situated that its beam cannot be directly brought to bear upon the piece of wood, endues it with this tendency to assume a polarity.

Not only is this result produced in such experiments, but a motion resembling that imparted to the steel needle by the refracted Moonbeam, is obvious, when sufficient time is allowed for the development of the magnetic influence: the piece of wood which had previously become polarised, will gradually change its position in such a manner as to suggest that the refracted ray of ordinary daylight can at last annul the tendency to reciprocate with the magnetic currents of the Earth, which tendency it first calls into action. The motion imparted is less rapid than that which is made manifest under the influence of the lunar spectrum, but the phenomenon is quite as decided.

Hence we may conjecture that, wherever there is light, when the ray of light is analysed by the prismatic refraction,—there is a concomitant development of that magnetic influence which interferes with the normal laws of gravitation, and which promotes, controls, and annuls certain grades of the gravitating forces. But it does not follow, that light, or the definitely limited rapidity of the ethereal action, (which we believe is necessary to our *ocular perception* of its effects) is the cause of this interference with the more simple laws of gravitation. In this and in all similar cases, it may be assumed, that the same force, which concurs with *physiological* ordinances in promoting *visual sensation*, has a distinct and more general *physical* influence over bodies, where there is no evidence of physiological arrangement,—and that this general magnetic influence may exist in greater power, when the action is so rapid as to prevent our appreciating its presence by means of the organs of vision.

All the phenomena of the polarisation of light, which occupy so large a portion of modern treatises on optics, will be found to harmonise with the *magnetic* hypothesis accounting for its origin. There are also certain laws in reference to our visual perception of physical activities in the *non-atomic* ether, which hold a relation to those under which our auditory organs are affected by the undulations of an *atomic* medium: both orders of laws seem to be under the influence of a similar numerical arrangement, as to intervals of spacial distance: but *seeing* may belong to a higher class of perception than *hearing*, the first being an *inductive*, the other a *conductive*, mode of attaining ideas of the activity of the external world, through the nervous system.

It is in accordance with our whole hypothesis, however, that visual perception should not be the *ne plus ultra* of physiological sensation. We may be satisfied that where the rapidity of the ethereal activity, or of the *throbs* of the all-pervading ether, ceases to affect the eye—there are physiological attributes of the nervous system in animated bodies which will enable the perceiving self to appreciate it. As regards inanimate bodies, the cessation of illuminating agencies does not interfere with active chemical agencies. The rays beyond the violet, which are too rapid to produce light, may be reasonably supposed to act more energetically in a magnetic mode than those which we see: that dark rays whose propagation is too slow to occasion light, promote more heat than those that are *visible* on the red side of the spectrum,—is a demonstrable fact.

That any animated inhabitant of this planet is enabled to appreciate the *physiological* power of the invisible but very rapid rays, is only a conjecture, warranted perhaps by some of the phenomena of animal magnetism,—upon which we may meditate in a future section. In other planets, *now*, (and if the theory of a continuous improving development of animal organisation upon this globe be well founded, even with respect to some future period in this Earth,) we may suppose the existence of animated bodies having a perceptive faculty as far above sight, as sight is above hearing,—adapted, however, in the great scheme of Providence, to that mere *physical* energy of inanimate matter, which is promoted beyond the violet ray of the solar spectrum.

The cause of much error in optical theories, is the want of an elementary analysis on the part of those who have most occupied themselves with delicate observations upon the nature of light: not only have they frequently confounded its physiological with its physical phenomena, but they have merged both the one and the other in the psychological idea of that sensation of ocular perception in themselves, which coincides with the development of certain changes in the constitution of vegetable bodies, as well as of those which are inorganic. It is far from the intention of the author to underrate their labours. The discoveries of the dark bands in the solar and sidereal spectra, and in beams transmitted through various gases, where the different arrangements of the bands seem to depend upon the differences of the illuminating bodies, or of the media through which the rays pass,—will open the way to speculations of a highly important character, if observers will bear in mind, that all such discoveries ought to be considered in reference to the varied rapidities of the rays. The polarisation of light, interesting as that subject is, will be found to be inferior in a general survey of the causes of optical phenomena to these discoveries, more especially when light itself is only regarded as one of the effects of a peculiar magnetic force in relation to the animal organ of vision, and when it is not confounded with its physical and elementary causes.

Some very interesting experiments may be made upon the prismatic influence of the solar beam, when it is brought to bear upon a needle floating on mercury. The density of the fluid metal offers an impediment to the motion of the needle itself; but any small portions of dust upon the surface of the mercury, will soon arrange themselves in curvilinear lines, and offer the appearance of oblong figures whose poles are the poles of the needle. It is probable, that in these experiments, whether the supporting substance be water or metal in a state of fluidity, the particles of its surface are *all* acted upon by the refracted sunbeam, and that this may partly account for the motion of the needle upon the water.

The author has not had an opportunity of continuing a series of observations in reference to such phenomena, with the care and attention they require; but enough has been remarked to authorise his recommending others to pursue these investigations. They may lead to very valuable inferences,—not only with respect to the different sorts of light, prisms, floating bodies, and media on which they float,—but in relation to the higher problem involved in the spacial changes which the particles and corpuscules of bodies so acted upon, undergo when they are exposed to the inductive influence of rays which are devoid of illuminating qualities.

SECTION XIV.

General remarks on the magnetic phenomena dependent on astronomical induction.

THE analysis of the phenomena of *astronomical induction* introduces the natural philosopher to a distinct class of laws, which every heavenly body obeys as if it were only an individual being, so far as its locomotion in space, and its active influence upon other heavenly bodies, are concerned: but each individual portion of the atomic matter which composes the outer layers, at least, of its substance, is more or less amenable to the concentrated astronomical influence of other celestial bodies. The relations of simple *gravitation* between the Earth and the Moon, elucidate this doctrine most satisfactorily. There is no *conductive* medium between these two bodies; they can only act upon each other by agitating the intervening ether, *inductively*; and *this mutual agitation occurs independently of the solar influence.*

A higher class of inductive influence is discovered, when we avail ourselves of the prismatic analysis. But according to the hypothesis expounded in the preceding sections, the *independent* magnetic forces of induction promoted by the *direct* reciprocity between the Moon and the Earth, cannot occasion light; and meditation upon the specialities of the solar spectrum leads to the inference, that the beam of no heavenly body can contain very influential "chemical rays," or high inductive magnetic powers, when the pulsating force which agitates the ether, produces impulses succeeding each other with a less rapidity than 450 or 500 billions per second. A greater rapidity than that of 750 or 800 billions of pulsations per second, is equally adverse to the promotion of the phosphorescent qualities of matter; but the physiological magnetic influence may be propagated in darkness, after the illuminating influence has ceased, although it cannot occasion the manifestation of light. The less rapidly promoted ethereal agitation would seem to be of a lower physiological order, than that which causes the development of phosphorescent qualities, or than that which is too rapid for the appreciation of the human eye. The experiments of Mr. Hunt prove, that *the red rays have a destructive instead of a vivifying influence upon vegetation,* even where light is produced; and they belong to the less rapid pulsations of the *visible* spectrum.

It has also been shown that both the Earth and the Moon may have other magnetic powers as regards their mutual influence upon each other's molecules, than those which are due to their separate *direct* reciprocity with the Sun; but this superior influence accompanies the manifestation of a secondary *inductive* process, which is usually considered as one of mere mechanical *reflection.* The force of the Sunbeam, in this *secondary* stage, exercises a much more refined magnetic influence upon the Earth than in the *direct* reciprocity, although its light has been greatly diminished, and its heat wholly extinguished, by what is called reflection from the lunar surface. But in the analysis of these phenomena, it would be incorrect to confound this *indirect* solar influence with the *direct lunar* influence, both of which agitate the ether within the cone-like region of space between the Moon and the Earth.

The modifications of the simpler forces which *are used* by the magnetic influence, are apparent whether that influence be derived from a terrestrial or an astronomical origin. But it may be proved that corpuscular elective tendencies are controlled and directed to certain ends, with a greater complication of cause and effect, in the higher, than in the lower processes of nature in either case.

Thus we find the phenomena of summer heat and winter cold occasioned by a periodical expansion and contraction, in certain parts of the globe, at certain seasons, which depend upon the relative energy of the solar inductive heating influence; while those of the tides are due to a simple attractive power called into activity by a rotation of the Earth's surface continuously bringing opposite the Sun and Moon a fresh longitudinal portion of the terrestrial substance. This globe, as *a whole*, has positive and negative *annual* relations to the Sun, which determine its elliptical locomotion; but in the case of the tides, the simpler gravitating force of one heavenly body acts upon portions of another without reference to the various modifications of the electrical force.

Again, when the magnetic rays of the spectrum change the poles of the needles, we observe the manifestation of a more refined change in the gravitating relations of the needle to other terrestrial bodies, and more especially to the internal nucleus of this globe. But the elective affinities of the chemical system exhibit a still more varied magnetic government of attractive and *elective* forces, than that which affects the relations of the poles of the needles to those of this globe: and every analogical argument is in favour of a progressive improvement in the administrative faculty of the magnetic influence, after the astronomical generation of new heavenly bodies by disjunction, has developed a new mode of transmitting that influence, which coincides with the absence of all contact, direct or indirect.

Now there is as decided a difference between *organic* and *inorganic* phenomena, as can be found between those which are promoted by the terrestrially and astronomically originated influences, which are both usually termed magnetic. Our hypothesis supposes, that the secularly self-developed change in the form of each particle or corpuscule may be interfered with by the neighbourhood of other portions of the same heavenly body: yet that when its constituent elements had been once brought together, they might have remained quiescent for centuries, if the external influence of other bodies were unimportant. But each *organic* compound of atomic matter is a system of *continuous and rapid instinctive activity*, in which there is an independent development of motion, deriving its *immediate* origin from *a special internal impulse.*

Every plant or animal resembles an atom in being kept alive by an inherent energy : but as the mechanical wear and tear of its organs is the secular cause of its death, the analogy, as regards the generation and dissolution of an *organic* system, is more extensively applicable to a heavenly body than to each individual atom; for the general argument militates against the assumption, that the atom can either generate a similar atom, or be subdivided into several parts. Still the analogy between the generation of a planet and that of an organic body, does not hold good in reference to the relation between the constituent parts of the parent and its offspring. The planets are generated *at the expense* of the solar substance; but the vegetable seed *grows* into the likeness of its parent tree, by aggregating to itself the neighbouring atomic matter: and the oak loses no more by the dropping of its acorns, than by that of its leaves. The generation and growth of the most insignificant cryptogamous plant indicates the development of a far more complicated process of Nature, than that which occurred when this globe became a distinct heavenly body, and gradually assumed its present conditions.

Hence it is obvious, that physiological laws are of a higher grade than those which prevail either in inorganic chemistry, or in astronomy: they give an aggregate of atoms the *automatic faculty* of producing its own likeness without any injury or permanent diminution of its substance, which faculty is only to be compared to that of the incorporeal impulse which increases instead of diminishing in power, after it has generated the atom itself. This comparison is peculiarly appropriate for another reason. The atomic force does not increase the number of atoms, or the quantity of atomic matter, however it may be distributed in particles or corpuscules; but the *generative* energy of living bodies does multiply the number of these systems to an immense extent: and such an increase is analogous to the development of *new sorts of force*, which multiplication of species and varieties of galvanic and magnetic currents is made manifest in the progression already expatiated upon.

Although the interpolar current of a heavenly body condenses all previous forces in itself, and reproduces them separately in a much more energetic state, as we have seen in reference to magneto-electric currents generated by galvanic currents,—this condensation of its combined forces is not to be compared to the infant potentiality, if it may be so termed, of the embryo atom, which, although not capable of developing the complicated forces in question, unless it had gone through several successive stages of combination with other atoms, must nevertheless have been *potentially* endued with the germs of them all. Still the inductive beam of the Sun contains *absolutely* within the same space several distinct inductive forces: they respectively promote the elliptical motion of this globe in its annual orbit, and the minor rise and fall of the tides,—the expansive and contracting influences which cause the *annual* differences between summer and winter heat, and the *diurnal* alterations of temperature depending upon the presence of the Sun above the horizon,—the *chemical* causes of that limited locomotion of particles moving in accordance with the fixed laws of elective affinity, which is developed most delicately when the colours of bodies are changed by exposure to the rays of the Sun,—and that *physiological influence*, which has been proved by actual experiments to hasten the germination of seeds, the hatching of eggs, the growth of plants, and many other progressive developments of vitality, which are generally attributed to the action of heat alone.

When we reconsider our conclusions about the phenomena of the solar spectrum, we cannot avoid perceiving the complete harmony which exists between the progression exhibited in that analysis, and in the hypothesis advanced in our whole essay upon the gradual development of the magnetic forces. The solar beam resolves itself under the prism, into a band of rays SPACIALLY *representing a certain period of* TIME, during which, as we suppose, atoms have undergone part of their secular contraction: this period, however, so far from being the whole time of the atom's existence, is only supposed in the present scheme to comprehend a little more than that portion of it, during which there is a development of phosphorescent qualities.

It is admitted in all theories of gravitation, that the atoms of *every* particle in a heavenly body contribute their *gravitating* powers to the general influence which promotes its inductive relations to another body. But the same doctrine must hold good in respect to the heating, illuminating, and magnetic forces, to a certain extent. Any atoms contracted to the requisite size, wherever they may be situated in the shell of the Sun or Earth, may have the faculty of transmitting the magnetic power generated in their ethereal envelopes, though those of the particle, of the corpuscule, or of the subordinate body in which that corpuscule is a constituent, until its constantly sustained energy is finally *brought out* on the surface of the heavenly body. It is, probable, however, that this progression is considerably interrupted by occasional interferences of the chemical accidents which may absorb such *secondary* forces, as those of molecular expansion or contraction, or of the agitation of the envelope of an atomic aggregate. But as the cause of the gravitating force in each atom is really the *aboriginal* impulse, the power of gravitation is a *primary* force, under all circumstances, and undergoes no diminution during its conductive propagation, because it originates in the substance of each atom; this is not the case with the forces which occasion the elective affinities of each atomic compound, or the circulating agitation of the layer of ether enveloping it: they are created, as it were, during the process of the formation of the particles and corpuscules, and change with their changes.

Hence it would seem, that the constant and unchanging gravitating force cannot be affected in the prismatic experiment: the *forces* which are obviously interfered with by the prism, are themselves, strictly speaking, *magnetic*, and liable to suspension or annihilation, because they are of a secondary character, and not congenital with the individual atom.

There can be no doubt of the existence of a solar influence, which acts as an impelling cause upon the atomic matter of this world; and observations of the most accurate character have established the doctrine, that the general sun-beam which is so necessary to vegetation, may be analysed, and divided into distinct portions—one of which excites such organic individuals as seeds and eggs to an extraordinary and rapid manifestation of their instinctive faculties of growth, while the other destroys that internal vital energy. Both these forces, when combined in the unrefracted beam, balance each other, and fulfil the intentions of Providence in relation to the general progression of the vegetable division of organic beings. The over-excitement of the animal frame, which would be occasioned by our breathing an atmosphere of oxygen, is moderated in a similar manner by the adequate mixture of nitrogen, which qualifies its stimulating powers. In both cases the natural synthesis has its relations of fitness to the organic world. The analytical prismatic experiments deal with the various sorts of astronomically-promoted magnetism, as those of the chemist do with the constituents of air.

When we advance in our practical application of the foregoing conclusions, and bear in mind, that in the general progression of nature, there is a continuous improvement and a development of new and more complicated physical systems, as regards *time*,—the reasonable inference is, that the inductive relations between the comprehensive interpolar currents of heavenly bodies will not only impel the atomic matter of this planet to occasional exhibitions of all those chemical phenomena, which are promoted by geologically originated impulses; but that they will enforce a higher order of results than any which are so produced by the electricity of the earth. That force, in the hands of the human electrician, can *hasten the growth of organic bodies;* and some experiments have raised a doubt whether it may not be applied to the more exalted function of *generating such bodies;* there is, however, a vast difference between these two classes of phenomena.

But to attribute to the magnetic influence of the inductive rays between bodies, a force capable of compelling the atomic substances of one of them to assume such relations to those of the other, as to cause the self-development of the germ of some very low animal, would be no bolder an hypothesis, than that which supposes the *vis insita* of the egg itself to have been originally endued with the power of developing all those progressively manifested faculties, which at last produce the form of the adult animal. The fact that the egg contains all the *latent* energies, which are necessary to this end, is incontestable. The physiologist never doubts about the still more wonderful life-producing sympathy between the male and female principles, which is shrouded in the mystery of fecundation.

One of the general harmonies of the progressive improvement of the whole physical system may be found in the concomitant development of separate heavenly bodies, and of separate living organisms. The idea of this parallelism is further supported by the considerations, that the disjunction of parts of a single heavenly body introduces us to a completely new system of physical action, and that there is no corresponding inorganic manifestation of force at all to be compared to the inductive sympathy between two heavenly bodies, unless it be the primeval agitation of the ether, which, as regards each atom, we presume occurred "in the beginning," between two incorporeal seats of energy, previously to the generation of the atom itself. That rectilinear inductive process is supposed to be the forerunner of the whole physical system, or of the entire *macrocosm* of our perception. It is the first stage of a continuously improving scheme of *inorganic* activity; but it at last introduces us to the gradual manifestation of numerous, collective, but independent schemes of *vitality*, or to those varied *microcosms*, in each of which there is a more or less complicated world of self-producing and self-sustaining modifications of vital *motion*, suited to the special design intended by Providence for each plant or animal—a design "perfect after its kind."

No subordinate aggregate of inorganic matter manifests this internal force, although it may have its own galvanic and magnetic currents of activity; for unless it be so situated as to hold external inductive relations to other atomic bodies, its currents would conduce to no ulterior object, and its special magnetic properties would only tend to the immovable fixation of its constituent parts. And when the reciprocating subordinate interpolar currents, left to their own tendencies in more compound inorganic bodies, do develop such phenomena of motion as volcanic eruptions, and geological catastrophes, and even the formation of new heavenly bodies,—there is nothing in these automatic displays of the physical energy worthy of being compared with one of these intricate, delicate, and transforming powers of organic bodies, which incorporate inorganic matter, and convert it into the prolific anther of a flower or the filament of an insignificant microscopic byssus.

In a *physical* point of view, the difference between a seed and an egg is not so marked as that which exists between an organic and an inorganic body. Both are special systems of vitality, and there is a parallelism in these two divisions of organised beings, which leads to their arrangement in one general class, as contradistinguished from inorganic compounds of atomic matter. *Metaphysically* and *psychologically*, the animal and vegetable are entirely distinct; and the parallelism in question inculcates an opinion, that the *aboriginal germs* of the plant and animal were first produced *under different conditions of the magnetic energy*; but the basis-idea of an internal *vital* motion is common to both divisions of organic beings, and all the arguments upon the long-debated and still-undetermined question of "the origin of species," are equally applicable to both.

After having gradually attained our position as regards the inorganic world, is it too bold an hypothesis to assume, that the origin of all living systems of atomic matter now existing upon the Earth's surface, may be attributed to an automatic aggregation of chemically composed bodies?—and that they were induced to arrange themselves in the simplest organic forms, in consequence of some highly refined electrical influence, which cannot be operative, until the gradual changes in the qualities of atomically composed inorganic bodies have developed an administrative magnetic power, which is adequate to the task of enforcing the designs of Providence, by so directing the lower energies of terrestrial matter, in reference to a special object, as to occasion the manifestation of physiological activity?

The same mode of reasoning is capable of a general application, be the reciprocating bodies in question, the Sun and any of his planets, or a planet and any of its satellites. The fixed stars themselves may have such relations of mutual influence, as to produce physiological phenomena on each others' surfaces, which are far beyond our notions of embodied intelligence, and of the nature of which no human experience can enable us to form an adequate conception. But should this speculation be unfounded, we have inferential evidence in favour of a transcendent influence, acting upon organic terrestrial bodies, when the solar magnetic powers are reflected upon the Earth by the Moon (according to conventional language), this physical operation most probably being a *compound* inductive reciprocity between the Sun and the Earth, which is propagated *mediately* and *indirectly* in consequence of the action of the Sun's magnetism upon the ethereal envelope which surrounds the Moon, and of a *contingent* sympathy between the Earth and the Moon, which is of a more refined nature than their *direct* sympathy.

If we are justified in looking to the magnetic relations of the heavenly bodies, as the highest stimulants and directors of the terrestrial forces which promote the development of organic forms, this borrowed and lunarly reflected influence of the Sun upon the Earth may be the most eminently-magnetic of any of the sympathetic powers by which the matter of our globe can be affected.

SECTION XV.

On the physiological influence of astronomically reflected light.

There is a marked distinction between the germination and growth of an organised Being on one side, and the mere stationary automatic maintenance of the individual's existence which depends upon such life-supporting processes as those of nutrition, on the other.

We are justified in attributing these separate classes of phenomena to different causes: and as we discover a more powerful magnetic influence in the lunar than in the solar rays, the analogy suggested by our experiment on floating needles, leads to the inference, that there may be a virtue in the *reflected* sun-beam, adequate to the promotion of changes in living bodies, which belong to a much higher description of physiological events, than those occasioned by its direct influence. The notion that the Moon is principally concerned in physiological generation, has been entertained from the earliest times, both by practical medical writers and speculative philosophers; while every language offers coincidences in the terms applied to the acts of the mind, in favour of the doctrine, that embodied intelligence upon our planet is in some way connected with the lunar influence.

The reader will find this subject very fully noticed in the *Dictionnaire des Sciences Médicales,* under the article "Lune," where the "influence attributed to the Moon in regard to animals and vegetables," is considered at length. Virey, the author of this article, quotes the following passage from La Place's "Essai philosophique sur les probabilités."

"The singular phenomena which are occasioned by the extreme sensibility of the nerves of some people, have given rise to various opinions in reference to a new sort of magnetic agent, (called animal magnetism), as well as the action of ordinary magnetism,—the influence of the Sun or Moon in some nervous affections,—and the impressions which may be occasioned by the neighbourhood of metals or running water. It is natural to suppose, that the action of these causes is very weak, and that it may be easily disturbed by accidental circumstances: therefore we must not deny its existence because it is never manifested in certain cases. We are so far from knowing all the agents of nature, and their different modes of action, that it would be unphilosophical to deny the existence of phenomena *because* they are inexplicable in the present condition of human knowledge; we ought to examine them with more attention, if it appears difficult to admit that they exist; and it is here that a calculation of probabilities becomes indispensable, in order to determine how far we should multiply our observations and experiments, so as to obtain evidence in favour of a probability, which may be superior to our arguments against it."

Virey prefaces this quotation by remarking, "that the question of the lunar influence is one of the most abstruse that can be discussed in natural philosophy, because we are only in possession of very vague *data* upon the subject, and they are obscured by a host of popular prejudices."

Prejudices of this description, however, ought not to pass unnoticed, for they are, for the most part, traditional and of such high antiquity, that they are interwoven in the radical terms of the oldest languages. μήνη, the Moon in Greek; *manas*, in Sanscrit; *mens*, in Latin; *man*, the word signifying the human race in so many languages of Europe and Asia; *Menu*, the sacred Indian lawgiver, and, according to his own account, the demiurgos or representative of Brahma; *Menes*, the first mortal king of Egypt; and, finally, *Men*, the name of the Divinity in so many oriental mythologies, are cognate words, which either connect the ideas of the origin of the human race, or of the incarnation of abstract intelligence, with that of the Moon. In the institutes of Menu, it is said in one place, (Chap. 1, sect. 66) that a month of mortals is a day and a night of the *Pitris;* and, in another, that these Pitris are perfectly pure beings, who inhabit the Moon,—a remarkable tradition when considered in relation to our physical hypothesis alone, independently of the harmonious psychological opinions of the Brahmins upon this subject, on which doctrines, however, we are precluded from remarking in an essay upon material laws. Virey goes on to say:—

"The first observers must have remarked constant periods in the pregnancy of women and female animals,—as well as in the number of days allotted by Nature, under ordinary circumstances, to eggs, which are exposed to the influence of incubation, before they are hatched: such observations, in connexion with the motions of the stars, which are the general standard of mensuration as regard periods of time, would naturally suggest a physical relation of cause and effect. These notions were most prevalent among the Chaldeans and Pythagoreans, who devoted themselves specially to the studies of astronomy and mathematics. Hippocrates, Aristotle, Empedocles, Diocles, and many others, applied them to physiological questions; and the influence of the mensual period upon women capable of child-bearing, is so undoubted, that they supposed all other animals were under the same apparently mystical power of Lunations."

"Ptolemy says, that when the perfect term of an embryo state is accomplished, as regards both plants and vegetables, the Moon must be in the condition in which it was, when the seeds were sown or when the animals in question were conceived. Pliny, Columella, and Palladius, in their agricultural treatises, make maxims of such rules: eggs are to be placed under hens at New Moon, according to these authorities, because the chicks will grow better *with* the Moon, than when she is on the wane; and it was generally admitted, that all animal and vegetable juices augmented with her increase, and became less copious after she had passed the full. Macrobius says, that the power of *perception* is derived from the Sun, but that *growth* emanates from the Moon, which is the generating force of animated beings; and that it imparts their *destiny* (τυχη) to human bodies."

Besides these, Virey adduces further quotations upon the subject which it is needless to repeat here: but they tend to prove that it was almost an universal opinion among the learned ancients, that the growth and pre-destination of organic beings depended on the Moon. As regards the hatching of eggs, it has been found in artificial incubation that no increase in heat will hasten the period, but that if the aid of electricity be obtained, the process is complete within a shorter number of days than that of the natural period. This is important in reference to the above speculations; because, if the *advancing* magnetic influence in the reflected rays of the Moon be peculiarly favourable to growth, while the application of an unusual electrical influence is equally beneficial and the cause of an *extraordinary* stimulating force in incubation,—it is a logical deduction, that the variable lunar influence, *depending on her phases*, does not arise from the *ordinary* reciprocity between the Moon and the Earth, but from that complex process, which, for want of a better word, we call reflection, when *induction* is promoted by the relations of *three* instead of *two* heavenly bodies.

There is no popular opinion more prevalent than that a derangement of the intellect is connected with a lunar influence; indeed *lunacy* is the most usual word expressing that disordered condition of the organs of human intelligence; and the changes in the Moon's phases are believed to coincide with alterations in the paroxysms in many cases of madness. Shakspeare's remark, that the Moon's "unwonted" proximity to the Earth "made men mad," has reference to this popular opinion. To sleep exposed to the moonlight is undoubtedly injurious to the sight, although its light is so inferior in intensity to ordinary day-light. Several modern medical writers insist upon the frequency of epileptic and apoplectic attacks when the Moon is full, or nearly so; headaches and a tendency to fulness of blood in the head, are more frequent at that period in persons subject to them, than at another; and wounds are more dangerous at that season, according to Baglivi. Lord Bacon fainted during lunar eclipses; and it is evident that if the influence of the Full Moon or the Sun be so important, the sudden cessation of either one or the other, must be productive of considerable effects upon the animal economy, which may be shown in persons of a peculiar frame of mind.

Van Helmont, and many other physicians, have remarked, that paroxysms of asthma coincide with lunar periods, and that when the Moon is on the wane, all disorders connected with the lymphatic secretions are most annoying. In cases of dropsy, the fatal symptoms are worse at that time. Hoffman gives an account of a woman born of a mother subject to epileptic fits, who was swollen in a peculiar way during the Moon's increase; but the swelling gradually diminished as the Moon waned. Baglivi also mentions a somewhat analogous case,—that of a young man afflicted with a fistula in the colon, which discharged an enormous quantity of excrements as the Moon increased; but this disgusting inconvenience diminished with that of the Moon's illumination. The quantity of urine and its quality, sometimes coincide in a similar way with the increase and decrease of the light proceeding from the lunar disc; the quantity of earthy sediment in many cases has been known to increase periodically during the decline; and it has been observed, that some persons subject to gout or venereal affections of the bones, are more or less affected by lunar changes.

In some fevers and epidemics, the evidence of similar coincidences are numerous and incontestable. The plague and the worst species of typhus fever seem to be particularly affected by the influence of the Moon. Ramazzini made accurate observations during the prevalence of a fever in 1692 and 1693; and he remarks, that it was much more dangerous during the wane and at New Moon, but that it was greatly mitigated when the Moon was on her increase: he lost many patients during an eclipse. Aristotle and Pliny both maintained, that when animals died a natural death, it was during the ebbing of the tide: and modern physicians have remarked, that such is frequently the case, when people die of fevers within the tropics; while those of an intermittent type often attack their victims at New and Full Moon. Lind, in his essay on the diseases of Europeans in warm climates, notices this coincidence, and particularly mentions the malignant effects of eclipses. Balfour in the Asiatic Researches (vol. viii), and Fontana in the Journal de Médecine (tom. 93, p. 335), have advanced similar doctrines.

After perusing the epitome of the evidence in Virey's article on the Moon, in the *Dictionnaire des Sciences Médicales*, we cannot avoid admitting the fact, that a lunar influence acts powerfully upon the animal economy; but he never notices electricity as an agent of change in such phenomena, and his method of accounting for the coincidence is so unsatisfactory to himself, that towards the conclusion of the article he gives way to the prejudices of incredulity, which are condemned in his quotation from La Place's Essay on Probabilities. Gravitation he supposes to be the sole cause of the predominance of fluids in the system at certain periods of a lunation, forgetting that the spring tides are the same at full as they are at new Moon, and that there is only a coincidence between his previously detailed pathological phenomena, and the conditions of reflected energy made manifest in the changes of light in the Moon during her revolution round the Earth, when the gravitating force does not undergo any change adequate to the promotion of such effects.

The above-mentioned observations about the effect of lunar eclipses in certain pathological cases, can only refer to an energy which is wholly distinct from the Moon's gravitating force : on those occasions there must be a cessation of some influence derived from the Sun. If there be truth in the remarks about the death of patients, in cases of plague and other violent fevers, during an ebbing tide,—and the testimony on this point is very decided,—the magnetic influence itself must be more influential after the Moon has been on the meridian of a place, than at any other moment; and it remains to be determined by observation, whether, as the tide rises twice during the lunar day, the fatal period is not that which coincides with the passage of the Moon over the meridian only,—a question which is not noticed in Virey's extracts.

Doubtless, the changes of the atmosphere which accompany both tidal periods, and the gravitating force of the Moon, may have their effects on the patient; but the ordinary rules of analogical reasoning enjoin a belief, that the daily passage of the Moon over the meridian, holds the same relation to the *monthly* climax of full Moon, as that of each *alternate high* tide to each *alternate season of spring* tide, at the time when the Moon and Sun are in opposition to each other.

The general observations in regard to the monthly changes, suggest that as the Moon increases, her magnetic force stimulates the germinating and growing processes of organic bodies; and that as she decreases, that energy diminishes. Hence it follows, that the pathological symptoms which accompany her entrance into the *third* quarter may be those of a *diminishing* energy in the diseased frame: but when she is increasing, even immediately after new Moon, the *tendency* may be one of melioration in the patient, although the quantity of her medicinal magnetism may be so much less *then*, than after she has passed her full. It is obviously to the *direction* of the magnetic change, or its tendency to increase or diminish, that we must look for the healing or the injurious influence in question;—not to the *quantity* of the stimulating energy which is developed at one time or the other. The fall of the tide *after* the Moon has passed the meridian of a place, is therefore much more likely to coincide with fatal symptoms in disease, than that fall which is occasioned by her having passed the opposite or antipodal point; because the magnetic power is on its decline in the first case, but it is on its increase in the other when she is returning to the meridian *from* the antipodal point. And this argument must hold good as regards the diurnal motion of the Earth, independently of her monthly change of position with respect to the Sun.

We have already observed, that it is in accordance with the rules of sound philosophy to distinguish between the stationary or mature condition of an organic body, and that early state of its existence when it is a germ or a growing system of vitality: but the *diseased* body is also under the prevalence of an occasional or variable influence which offers a decided contrast to that which maintains its automatic functions in a normal state during health. The rays of the Sun are undoubtedly endued with a powerful magnetic energy; and the difference between the force of vegetation on various parts of the Earth,—its violent activity between the tropics,—its inertness at all times near the poles of the Earth,—and its temporary cessation during winter,—afford evidence in favour of a solar influence, which is indispensable to the development of vitality upon the surface of this globe.

It is one of the laws of nature, that both animals and vegetables should be in different states when the Sun is above or below the horizon: the general rule is, that they should be awake during the day, and that they should sleep at night; and this is most obviously shown in the long periodical sleep of hibernating animals, which resembles the inertness of plants during winter. The causes of these phenomena are not demonstrated by the correct assertion, that there is a fitness in such adaptations of physiological laws to the absence or presence of light; the intensity of the solar influence is the immediate cause, but as it only acts on certain animals, there must only be a *sympathetic relation* between that influence and certain organs in *them, but not in other animals*, which is connected with the waking state of their perceptive or mental qualities.

It is not assumed in our hypothesis, that the mystery of *animation* is to be explained by attributing an animating energy either to the solar or the lunar influence. Vitality is a property common both to animals and vegetables, and *organs* of perception, intelligence, or reason, belong in various degrees to many animals; but their *animality* is a homogeneous quality *sui generis*, *confined to one sentiment only—that of* BEING IN EXISTENCE. The *individuality* of this *basis* of the lowest animal perception or of the highest human reason, precludes us from attempting to analyse the ANIMATING PRINCIPLE; and speculations upon the subject belong to the highest problems of metaphysics, which we do not venture to approach in a treatise confined to the examination of material phenomena.

But we have been led on by a progressive method of argument, to the speculation, that organic *vitality*, and perceptive, as well as intellectual, organs, are properties of animated bodies which are generated by a physical influence of an electrical character: and that this occurs upon the surfaces of astronomical bodies, which hold inductive relations to each other. A lower order of physiological phenomena seems to be connected with the *direct* reciprocity between the Sun and the Earth; a higher with the *indirect* reciprocity between them, through the agency of a third heavenly body, which, however, is incompetent to the transmission of those heating sympathies, that accompany the magnetic rays of the solar beam.

Now, according to this notion, the lunar beam is a stimulating agent of nature, as regards this globe, which conveys an impetus to terrestrial matter, promoting the development of a continuously improving automatic system —a germinating force—a growing energy—and a medicinal influence over organic bodies, whose *normal* conditions have been impaired by disease and accident. The solar beam may have these powers *now*, to a certain degree; and if the general hypothesis be correct, the Sun will manifest them much more bountifully when his atoms are more contracted : but the Moon's reflection of solar magnetic rays, and her proximity to the Earth, may render her the principal dispenser of such benefits at present,— although the Sun's power is more constant and even, while her's is uneven, or occasional, in consequence of her lunations. And we have arrived at the conclusion, that although the Sun is necessary to vitality (perhaps he may promote it), the Moon's influence may be concerned in the conception, germination, and growth, of the whole animal world, including those mysterious portions of the nervous system, which embody mind itself.

Thus we are gradually brought to the consideration of three great subjects of philosophical meditation—namely, the origin of species,—phrenology,—and animal magnetism. Those who support the doctrine of animal magnetism, contend for the existence of a sympathetic force between animals, which is perfectly analogous to the reciprocity between heavenly bodies, considered in this treatise as the magnetic stimulating instrument of an intelligent Providence, by which matter is, as it were, *charmed* into acts of physical, chemical, or physiological appetency.

If vitality, or the nervous apparatus destined to maintain life, be distinct from thought and perception, or their corporeal organs—it harmonises with the progression developed in Nature, that both light and the higher order of magnetic excitement should have been unnecessary when neither sensation nor intelligence were embodied in material forms. And as we have already supposed that there was a time when no light was developed in the solar system,—while geologists assume that this globe was formerly uninhabited by animals,—we are justified in enquiring, whether solar light itself, which is a visible test of an inductive agitation of the ether, may not be the coincident of some advanced modification of vital organisation, and whether it does not hold the same relation to the physical *macrocosm*, as that of the organs of *visual* perception to the rest of the physiological *microcosm* in the animal body. The light of the sun is necessary to the highest animals, for that of the moon during a part of a lunation is altogether null.[y]

Our general hypothesis, however, assumes, that light diminishes, and is, at last, altogether extinguished, as the atomic constituents of a body continue to contract,—but that the magnetic influence becomes more and more powerful, as the stimulator and controller of the gravitating forces, after the cessation of this phosphorescent action. The analogy therefore leads to an inference,—that the mental faculties of animated bodies upon this globe will be more perfect, when their sense of seeing is lost; and as the eye (physiologically speaking) is the most refined

[y] The reader will not fail to perceive, that this hypothesis about the non-existence of light-producing rays, until the general substance of a heavenly body has attained a high degree of consolidation—militates against the assumption that the visible nebulæ can be otherwise composed than of distinct stars.

special organ of communication between the self and the external world, we are justified in the conjecture, that its want will be supplied by some other instrument having still more extensive powers. The hypothesis, that when the inductive influence of magnetism has undergone the astronomical process which we call reflection, it is rendered a far more stimulating director of the atomic forces, will harmonise perfectly with the above mode of reasoning: and the phenomena of animal magnetism may belong to a higher order of perceptive as well as of intellectual faculties, than those which depend upon the ear or eye.

Be that as it may, the direct influence of the solar beam has a considerable influence upon all animals; his light, and not that of the Moon, is the essential medium of our sight; but a much higher, and (if it may be so expressed) a *purified* condition of his magnetic rays, when they alone operate upon terrestrial matter, may be necessary to the development of all animal powers of perception. It must be admitted that *all* planetary bodies in his system are capable of reflecting the magnetic rays upon each other; but it is no less certain that the moon is that reflecting body which is the most important as regards the earth, in consequence of its proximity to us.

Hence arises the conjecture, that those planets which have no satellites are either uninhabited by animated forms of matter or tenanted by the lowest and most zoophytical of such beings. There may be no animals in Mercury, Venus, and Mars, if the quantity of *reflected* and sublimed solar magnetic rays be the regulator of the extent to which atomic matter can become an instrument of refined sensation and intellect; Saturn or Jupiter, on the contrary, may be peopled by corporeal beings, whose superiority over our race may surpass our most romantic imaginings about the possible perfection of an embodied mind.

The general supposition that astronomically reflected magnetic and illuminating influences are intimately connected with physiological development upon the surface of this globe, holds good whatever may be the size and distance of the body which occupies the *medial* position between the Sun and the Earth's surface: but the *quantum* of the effect upon animated forms of matter must be determined by the relative distance and size of the reflector. No heavenly body has the advantage of being so near the Earth as the Moon is; and as this gives an apparent size to her disc, when she is full, which nearly equals that of the Sun,—we may suppose that the spacial quantity of *indirect* magnetic influence in one case, is nearly equal to that of the *direct* influence, in the other; while the absence of any heating rays in the moonbeam, and the superiority of its interference in relation to the reciprocity between the poles of the Earth and those of a needle, will coincide with the assumption of its being so much more powerful as a magnetic agent, than the beam proceeding *directly* from the apparently equal superficies of the solar disc, because the mode of its generation implies a more advanced stage in the general progression than that of the *direct* sunbeam.

Since all the planets are visible in consequence of reflected light, their mutual magnetic influence upon the organised beings which inhabit their surfaces, if that influence *generally* be adequate to the promotion of great physiological changes, must be in proportion to their distances from each other, and to their respective discs. As we have every reason for believing that wherever there is light, there is a sympathetic ethereal agitation which produces this magnetic influence,—every visible star, be it fixed or planetary, must have some magnetic influence upon organic terrestrial matter, however minute and comparatively insignificant such an influence may be. Venus, Mars, and Jupiter, which are the powerful planets nearest the Earth, (always excepting the Moon), would be the most potent reflectors of the magnetic power. The fixed stars, however, could only affect the

Earth in the same manner as the Sun does; that is to say, by a direct, not by reflected influence: and their distance from us is so great, that any magnetic influence of theirs must be very weak, although we see them. Not so the effect of the planets, which from their size or proximity are able to cast a shadow on the Earth's surface.

The astral influence for which we are contending, is not that empirically-imagined power, which is called malignant or benign in astrological tradition, according to the star from whence it proceeds; but a physiological force of an uniform character, the relative conditions of which may depend on the bulk of the planet, the contraction of its atoms, and its varying distance from the heavenly body, with the surface of which it sympathises. It may be, that where the distance is very variable, as in the case of Mars, there is a more irregular agency at work than in that of Jupiter, where, although the bulk is greater, there is less variation in its distance from the Earth; but this may be scientifically explained. That the planets have a magnetic influence is incontestable, if the Moon be so endued; and that the two constant forces of gravitation in the Moon (one of which raises the tides, whilst the other occasions irregularities in the Earth's movements) are altogether different from this reflected and occasional magnetic influence, is evidence in favour of a distinction between the *magnetising* power of such a planet as Jupiter, and the interference of his *gravitating* force with the motions of our globe.

SECTION XVI.

On the origin of species, and the theory of their transmutation.

Geologists are almost unanimous in maintaining,

1st. That every species, genus, or family of plants and animals has been formed or developed within an appreciable period; and

2ndly. That, as regards the appearance of both sorts of living beings (vegetables and animals), there has been a gradual development, in which the *direction* of the general progression exhibits a continuous tendency to improve:—the most modern species being a more complicated system of organization than any other which was developed previously.

But before geology furnished such decided inferential evidence in favour of the botanical or zoological systems being the manifestations of one general progression, anatomy had established the doctrine,—that existing plants or animals are the links of two great categories, in which certain leading principles of arrangement are dominant; and that the differences between the highest and lowest individuals in either of these departments of organic beings might be accounted for, when the intermediate links were examined. Some of these connecting species, however, are extinct; but subsequent geological discoveries supply the deficiency in many instances, by bringing to the test of ocular observation, the remains of plants or animals which were wanting to complete a series. Thus genera, and orders of animals supposed by the naturalists of the last century to be entirely distinct, are now connected in well-considered systems of classification by the remains of such extinct species as the Sivatherium. Newly discovered living animals (the Ornithorincus and others), have also contributed to fill up the voids in the older schemes. It may, therefore, be laid down as a general rule,—that throughout nature, there has been, and *still is*, a constant tendency to advance in the improving ratio from the simple to the complicated.

This conclusion is an important analogical argument in support of the opinion, that *species* of a genus hold the same general relation to each other, as that which exists between *varieties* of a species; in other words, that the individuals of one species derive their origin from those of another, through the intervention of numerous intermediate races during a very long period; while the difference between the two species in question, is the result of a gradual succession of very slight changes in the organization of each race. This hypothesis may be extended to the annihilation of any *permanent* characteristics of genera, families, orders, or classes of animals and vegetables.

Should such a doctrine be correct, we are obliged in consistency to admit, that all the higher animals (man included) derived their origin from some lower and less complicated forms of animated material systems,—more especially if it be a general principle, that the progression is one of continuous improvement throughout the entire solar system. It is a further deduction from this premise, that there are as many chances in favour of the development of an animal organization, more perfect than that of the most highly gifted human creature, and of its existing on this globe at some future period,—as there are, or have already been, different genera or species of animal inhabitants upon its surface.

Thus the question of the *origin* of a species is resolved at last, by this method of reasoning, into the following problem:—

How was the first *individual of a succession generated, supposing it to have been the aboriginal ancestor of a continuously improving series of descendants?*

While we dispassionately investigate this subject, it may be satisfactory to review the arguments for and against the doctrine, that every species is capable of permanent change. There is no question in philosophy which has more engaged the attention of the first authorities in natural science, nor one upon which men of undoubted philosophical ability have been more divided.

Tiedemann is one of the naturalists who have discussed it the most at length. In his treatise on "Human Physiology," he has published a compendious dissertation upon the parallelisms between living and inert or inorganic bodies. Not only does he support the doctrine of the gradual automatic progression of the animal and vegetable systems, and the improving transformations of simple species into those which are more complicated, and therefore more perfect; but he believes in the *spontaneous* generation of the lowest or most simple forms of an organic body.

He says, Book I. sec. xx. "If we extend our inquiries, we have to determine how organic substances, their different combinations, and living bodies, are formed in our planet. The solution of this problem is not to be aided by our experience; and when we endeavour to solve it, we are obliged to establish hypotheses, which may be more or less plausible; but they have not the value of certainties. We suppose,—either that organized bodies have existed upon the Earth from its commencement,—or, that organic substances and living bodies have been formed out of inorganic elements and substances, by the action of physical causes, under certain circumstances,—or that the substance of living bodies was originally contained in water, as primitive organic matter endued with the quality of assuming organic forms; that it has given birth to very simple organic bodies, varied by circumstances; and that these bodies have passed successively into more complicated forms, until, in consequence of the development of generative organs, and manifestations of other active functions, they were enabled to keep up the specific succession, by the faculty of generation."

He then says,—the first of these hypotheses (which assumes that organic bodies have existed upon the Earth from the first moment of its creation), is hostile to geological observation.

He objects to the second hypothesis,—which supposes that inorganic matter could become organic, because no observation justifies its adoption, as we have never witnessed any phenomenon capable of furnishing an analogical argument in its favour. He inclines to the third hypothesis,—that the substance of organic bodies existed primevally in water, as matter of a particular sort,—that it had "a *plastic faculty*, that is to say, the power of acquiring, by slow degrees, different simple forms of living bodies, when aided by the general influences of light, heat, perhaps of electricity, &c., and of their passing from such simple to more complicated forms, varying in accordance with the modifications of external influences, until at last each species acquired a durable character in consequence of the activity of its generative organs."

Now in reviewing this opinion to which he attaches himself, we cannot fail to observe the want of extension in his analysis of phenomena. In such recondite questions, it is impossible to avoid beginning in an hypothesis; he so begins: he commences, however, with the geological argument, which is undoubtedly most important: but he never inquires how water itself was formed; and he takes no notice of any astronomical question connected with the origin of the planetary body which we inhabit. As *water* is not a simple chemical substance, his self-imposed limitation, which makes *that* compound of oxygen and hydrogen the primeval medium, is the more extraordinary.

The consequence of this has been his adoption of a circumscribed *plastic* theory. Such a theory, so far as it goes, is supported by the phenomena both of physiology and geology, nor is it hostile to some chemical and astronomical theories. But if it be admitted, the same method of argument leads to the adoption of his second instead of his third supposition, or rather to that of the second and third as members of the same hypothesis,—

namely, that *inorganic matter, under certain circumstances, is so acted upon by a general* plastic *force, that it becomes organic.* If the progression of complication began long before any planet was in existence, the *first* comprehensible physical or chemical manifestation of action, is as much part of the progression, as the *transmutation* of the non-generating organised body into one capable of maintaining the species by generation, is; and there is an analogy between the force of the germ in the egg of a bird, and that of the original force which occasioned the development of each atom in the solar system.

Thus that potential or latent energy, which Tiedemann ascribes to organic matter suspended in water, according to his idea of " a beginning," and which, he believes, is capable of being at last developed as the active cause of vitality and of intellect itself,—is only a link in the chain of forces, which, according to our more extensive hypothesis, pervades the entire system of material activity.

In his twenty-fourth section, he says: " another circumstance favourable to the hypothesis of the gradual development of organic bodies, from the most simple to the most complicated, is the fact,—that all vegetable and animal bodies appear in their most simple forms at the moment of their generation, or when their germs advance to maturity; and that it is only by degrees that they acquire the complication of form peculiar to each species. To begin under simple conditions, and to advance towards those which are most complicated, is the general property of all symptoms of life, whether a single individual or the entire zoological world be the object considered."

These opinions in favour of the continuous improvement of successive generations, have been less adopted in England than in other parts of Europe. Our most eminent living geologists are inclined to believe, that each existing species is a distinct system, the first individuals of which were created with the same forms, or nearly the same, as those which are its present characteristics.

Professor Buckland, who has done more to make geology popular in England than any other writer, says, in his *Bridgewater Treatise*, " In these most ancient conditions, both of land and water, geology refers us to a state of things incompatible with the existence of animal and vegetable life: and thus, on the evidence of natural phenomena, establishes the important fact, that we find a starting point, on this side of which, all forms, both of animal and vegetable beings, must have had a beginning. As in the consideration of other strata, we find abundant evidence in the *presence* of organic remains, in proof of the exercise of creative power, and wisdom, and goodness, attending the progress of life, through all its stages of advancement upon the surface of the globe; so from the absence of organic remains in the primary strata, we may derive an important argument, shewing that there was a point of time in the history of our planet (which no other researches but those of geology can possibly approach) antecedent to the beginning of either animal or vegetable life. This conclusion is the more important, because it has been the refuge of some speculative philosophers to refer the origin of existing organisations, either to an external succession of the same species, or to the formation of more recent from more ancient species, by successive developments, and thus to deny the existence of any first term in the infinite series of successions which this hypothesis assumes. Against this theory, no decisive evidence had been accessible, until the modern discoveries of geology had established two conclusions of the highest value in relation to this long-disputed question: the first proving that existing species have had a beginning; the second showing, that they were preceded by several other systems of animal and vegetable life, respecting each of which it may no less be proved, that there was a time when their existence had not commenced: and that to these more ancient systems also the doctrine of eternal succession, both retrospective and prospective, is equally inapplicable."

Sir H. de la Beche supports the same doctrine, in one of the most interesting of his many excellent works, his *Geological Researches*; but he does not attempt to overturn the evidence in favour of the propositions,—that all the earlier species are extinct, and that the progression has been from the simple to the complicated.

In Mr. Murchison's valuable and splendid book on the Silurian region, he has given us details upon this subject which are of the greatest importance. He says (p. 582), "Each period of change, during which the surface of the planet was essentially modified, was also marked by the successive production and annihilation of certain races. This territory [his so-called Silurian region], when examined carefully and in all its parts, presents us with many examples of a perfect 'sequence' in the succession of the strata, and the progressive development of the zoological contents. Thus, certain species, whether endowed with powers to resist vicissitude, or living in those parts where few active causes of destruction were at work, continued to live through long epochs; while others of a higher structure passed away in comparatively short periods."

"There is, however, a phenomenon of the highest importance connected with the distribution of organic remains in the older strata, which has not been adverted to, namely, that the same forms of crustaceans, moluscs, and corals, are said to be found in rocks of the same age, not only in England, Norway, Russia, and various parts of Europe, but also in southern Africa, and even at the Falkland Islands, the very antipodes of Britain. This fact accords, indeed, with what has been ascertained concerning the wide range of animal remains in deposits equivalent to our oolite and lias; for, in the Himalaya mountains, at Fernando Po, in the region north of the Cape of Good Hope, and in the run of Cutch, and other parts of Hindostan, fossils have been discovered, which, as far as the English naturalists who have seen them can determine, are undistinguishable from certain oolite and lias fossils of Europe.

"Another remarkable fact illustrating this point of inquiry is, that although the older fossiliferous strata often contain *vast quantities* of organic remains, *the number of species is much smaller* than in more recent deposits."

Again, in the 584th page, he adds: "We find that, in the ascending geological series, the quantity of species increases considerably as we approach the younger deposits, and that in proportion to this increase, their geographical distribution harmonizes more and more with that of existing Nature." His conclusion is: "If the existence of formations, so nearly universal as respects the surface of the globe, be admitted, it would seem to be a fair inference, that however we may explain it, there must have then prevailed a generally equable temperature."

But a still more important inference, as regards the question of progressive development, now under consideration, is, that the small number of different species and their universal diffusion during the older geological periods, accords perfectly with the general scheme of Lamarck and others, who contend, that the gradual tendencies to improve and assume new organic forms, ramify in various directions like the branches of a tree, and are divided and subdivided, each small twig holding an analogy to each species or variety of animal or vegetable.

Indeed there is scarcely any difference between modern geologists upon the existence of a *continuously improving* tendency of this description in the gradual development of

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organic systems upon the surface of our globe. Mr. Lyell is almost alone in his opinion upon that point; and even he admits, that man, the most perfect animal, was the last formed, which admission obliges him to attempt the establishment of distinctions between the human race and other animals that are not altogether warranted by physiological argument.

D'Omalius D'Halloy, in his *Elémens de Géologie*, from section 755 to the end of the work, offers a theory of geological formation, beginning with the assumption that the whole matter of the earth was liquid. He argues upon *data* which are completely mechanical, and enters into a detailed speculation upon the gradual "coagulation" of its surface, and of the gradual loss of its heat by radiation. Sir H. de la Beche, in his geological researches, resorts to a similar method of getting rid of the heat, which, by the way, is inadmissible in our theory; but neither they, nor any other geologist holding these opinions about the disappearance of the heat, attempt to account for its origin.

D'Omalius D'Halloy enters upon the precise question now before us, in his 763rd section. He supposes that no animal could have lived in a very elevated temperature, and that *vitality* was not developed on all parts of the solid terrestrial surface at the same time,—but that animal and vegetable forms of matter were both at first made manifest under simple conditions of organization, wherever that surface was fit for their abode.

As to the succession of living beings, he says, sect. 765, "The successive changes in the nature of the living beings which have inhabited the surface of this globe, induce us to examine whether there have been many creations,—or whether there have been merely partial distinctions occasioned by geographical causes,—or whether the re-productive process of Nature could have promoted the graduated succession of those different forms which we observe in the layers of the Earth. The notion of a series of distinctly new creations is a perfectly gratuitous hypothesis, which is supported by no analogy in regard to phenomena that have occurred within the historical æra; and we are not justified in adopting similar hypotheses, unless it is impossible to explain the fact otherwise, which is not the case in the present instance.

"Undoubtedly a partial destruction of vegetable and animal beings has taken place on certain occasions: thus when the sea has covered an island or an entire continent, all its terrestrial animals must have been destroyed, and succeeded by marine animals; in the same way, as the contrary must have occurred when the bottom of the sea became dry land. We can also understand, that changes of temperature, or the multiplication of carnivorous animals and of the human race, would have occasioned the disappearance of certain species; but if the changes in living Nature had only occurred in this manner, it is a strange chance that in the lower strata we do not find the remains of beings which resemble existing species. It is a second and no less extraordinary chance that living beings should have been distributed upon the Earth's surface in groups presenting to our view systems of organization which, although based on the same general plan, should have all differed from each other to a greater or less extent, and should offer such a regular progression of complication as that which appears in the fossil of the successive layers of this globe's crust. It is a third and still more extraordinary chance, that the destruction should have progressively obliterated groups, which least resemble those now in existence,—that the countries in which we discover their remains should only have been inhabited by such groups, if the more modern were simultaneously in being,—that such groups should have been regularly and successively replaced by others having a greater affinity to living species, to such an extent that when the deposition of the series of layers in any particular spot has not been interrupted, or when the changes of organic remains do not demonstrate that there has been an invasion of the sea in that locality, the changes occur in an almost imperceptible transition; and finally that we should find new forms at first accompanied by older ones, which soon disappear altogether and are not renewed.

"The hypothesis,—that these changes have been occasioned by a progressive improvement in the organic system accompanying the ordinary mode of generative reproduction,—may be attacked by persons who maintain, that existing species have a stability incompatible with such a gradual development. But however decided such a stability may seem, it cannot be called the *absolute* quality of a species; and if we examine the history of living beings in reference to the assumption, that the species to which they belong are incapable of being so changed, we shall find that very decided alterations of form do take place.

"Human interference, by augmenting, diminishing, or varying the nourishment of such beings, or by changing the temperature of the medium which they inhabit, has made single flowers double, has rendered fruit larger and more succulent, and has given to domestic animals such new and varied forms, that zoologists are obliged to group together, in the species *canis*, a collection of animals differing from each other to a greater extent than the fox does from the wolf.

"Changes of this sort occur without the interference of man, in consequence of changes of circumstances affecting living beings. The Spanish horses which have become wild in the burning *pampas*, or cold *paramos*, of South America, have produced two races, which are as different from each other, as the ass and the zebra. Even if we examine our own species, we find that the peculiar diet of a nation, or certain family professions, give nations or families peculiar forms which are inherited. Now, it is evident that all these causes of change must be much less operative than those brought about by geological means. The external heat of this globe—the gradual diminution of this heat—the nature of the atmosphere in the older periods—the new gases which are constantly changing its composition at all times—the mineral nature of water, which undergoes continual alterations—all these causes must influence the vital action to an extent which we cannot appreciate, but which may be sufficient to account for progressive changes in the forms of the animals and vegetables of different periods."

Cuvier, in his *Discours sur les Revolutions du Globe*, argues at length against the transmutation of species; but as he bases his arguments upon the fact, that animals which have been preserved in the oldest Egyptian tombs, or are sculptured on the oldest monuments, do not differ from existing species, they will not have much weight with the naturalist, who considers four or five thousand years too short a period for the transmutation of a series from one specific form to another. Still Cuvier is one of the most decided supporters of the doctrine, that the whole zoological series exhibits a progressive system of improvement, not merely as regards existing species, but with reference to fossil remains of animals; upon which he founds his opinion, that the improvement in question has been continuous from the earliest geological era, although he believes that each such change of form required a new creation.

M. Boué, in his *Géologue Voyageur*, is hostile to the theory of there having been a progression of this sort from the simplest to the most perfect form of organic bodies. He says, "Generally speaking, the different creations either of vegetables or of animals, when considered *en* *masse*, do not lead to the notion, that the most complicated were not produced until the most simple forms had been in existence."

He then goes on to say, "According to my idea, which is neither that of the Biblical school, nor that of Mr. Lyell, the creating forces of nature have been the same at all epochs, and are now what they were before man appeared upon the earth: but certain accessory circumstances were necessary to their energetic manifestation;—for instance, certain ambient *media*, certain quantities of different sorts of gases, certain intensities and activities of the electro-magnetic fluid, of light, &c."

"Now it is in conformity with this notion, that all classes of vegetables and animals, man included, would have been created during the earliest geological periods of nature, if the conditions of their respective organizations had allowed it: but the accessory circumstances being such, that the life of one or of many of these classes, was impossible; it follows, that all of them would not have appeared at the same time,—that some were only able to create themselves at certain epochs,—and that those that formed themselves the first, only had that advantage in consequence of special modifications suited to their respective present conditions. It was above all things necessary, that there should be a suitable medium. At present the medium is such, that the creative process is restricted to the lowest beings, namely, those which are intermediate between animals and vegetables, to certain genera of infusoria, and, perhaps, to intestinal worms."

It may be observed, however, that this hypothesis of M. Boué's, which exceeds Lamark's in boldness, deals in a general and vague way with intensities and activities, which is not allowable, when a theory is propounded, even discursively, in opposition to that of almost every brother geologist. The hostility of Mr. Lyell to the doctrine of a continuously-improving progression is more measured in its language, and founded upon much more detailed observations. In truth, there is little or no difference between the theories of Mr. Lyell and M. Boué. Both these geologists are hostile to the doctrine, that the more perfect species have, generally, been preceded by the less perfect.

Mr. Lyell has not, like M. Boué, speculated upon the nature of the agency, by or through which the first individuals were developed ; he offers long and very interesting remarks upon " the original introduction of species,"— " the changeable circumstances which constitute the stations of animals,"—" the influence of inorganic causes in changing the habitations of species,"—and " the extinction and creation of species ;"—all which questions are examined in the 8th, 9th, 10th, and 11th chapters of the 3rd book of his " Principles of Geology."

His speculations on the appearance of new species are exceedingly guarded ; for towards the close of the last of these chapters, after demonstrating that the *annual* new appearance, and *annual* annihilation of a single animal species, might only occasion the disappearance of one species of mammifer in forty thousand years,—he infers that in such countries as " England or France, periods of much greater duration must elapse, before it would be possible to authenticate the first appearance of one of the larger plants and animals, assuming the *annual* birth and death of one species to be the rate of vicissitude in the animal creation throughout the world."

" The observations of naturalists, upon living species, may," he says, " in the course of future centuries, accumulate positive data, from which an insight into the laws which govern this part of our terrestrial system may be derived ; but, in the present deficiency of historical records, we have traced up the subject to that point where geological monuments alone are capable of leading us on to the discovery of ulterior truths. To these, therefore, we must now appeal, carefully examining the strata of recent formation, wherein the remains of *living* species, both animal and vegetable, are known to occur. We must study these strata in strict reference to their chronological order as deduced from their superposition, and other relations. From these sources we may learn which of the species, now our contemporaries, have survived the greatest revolutions of the earth's surface; which of them have co-existed with the greatest number of animals and plants now extinct, and which have made their appearance only when the animate world had nearly attained its present condition. From such data we may be enabled to infer, whether species have been called into existence in succession, or all at one period; whether singly, or by groups simultaneously; whether the antiquity of man be as high as that of any of the inferior beings which now share the planet with him, or whether the human species is one of the most recent of the whole.

"To some of these questions we can even now return a satisfactory answer; and with regard to the rest, we have some data to guide conjecture, and to enable us to speculate with advantage: but it would be premature to anticipate such discussions until I have laid before the reader an ample body of materials amassed by the industry of modern geologists."

In the close of his 16th chapter of the same book, in which he advocates the recent origin of man, we find the following remarks: "I cannot conclude this chapter without recalling to the reader's mind a memorable passage written by Berkeley a century ago, in which he inferred, on grounds which may be termed strictly geological, the recent date of the creation of man. 'To any one,' says he, 'who considers that on digging into the earth, such quantities of shells, and in some places bones and horns of animals, are found sound and entire after having lain there in all probability some thousands of years; it should seem probable that guns, medals, and implements in metal or stone might have lasted entire, buried under ground forty or fifty thousand years, if the world had been so old. How comes it then to pass that no remains are found, no antiquities of those numerous ages preceding the Scripture accounts of time; that no fragments of buildings, no public monuments, no intaglios, cameos, statues, basso-relievos, medals, inscriptions, utensils, or artificial works of any kind, are ever discovered, which may bear testimony to the existence of those mighty empires, those successions of monarchs, heroes, and demi-gods, for so many thousand years? Let us look forward and suppose ten or twenty thousand years to come, during which time we will suppose that plagues, famine, wars, and *earthquakes*, shall have made great havoc in the world; is it not highly probable that at the end of such a period, pillars, vases, and statues now in being, of granite, or porphyry, or jasper, (stones of such hardness as we know them to have lasted two thousand years above ground, without any considerable alteration) would bear record of these and past ages? Or that some of our current coins might then be dug up, or old walls and the foundations of buildings show themselves, as well as the shells and stones of *the primeval world*, which are preserved down to our times.' "

After offering this extract from Berkeley, Mr. Lyell proceeds: "That many signs of the agency of man would have lasted at least as long as 'the shells of the primeval world,' had our race been so ancient, we may feel as fully persuaded as Berkeley; and we may anticipate with confidence that many edifices and implements of human workmanship, and the skeletons of men, and casts of the human form, will continue to exist when a great part of the present mountains, continents, and seas, have disappeared.

Assuming the future duration of the planet to be indefinitely protracted, we can foresee no limit to the perpetuation of some of the memorials of man, which are continually entombed in the bowels of the earth or in the bed of the ocean, unless we carry forward our views to a period sufficient to allow the various causes of change, both igneous and aqueous, to remodel more than once the entire crust of the earth. *One* complete revolution will be inadequate to efface every monument of our existence ; for many works of art might enter again and again into the formation of successive eras, and escape obliteration, even though the very rocks in which they had been for ages imbedded were destroyed, just as pebbles included in the conglomerates of one epoch often contain the organised remains of beings which flourished during a prior era.

Yet it is no less true, as a late distinguished philosopher has declared, 'that none of the works of a mortal being can be eternal.' They are in the first place wrested from the hands of man, and lost as far as regards their subserviency to his use, by the instrumentality of those very causes which place them in situations where they are enabled to endure for indefinite periods. And even when they have been included in rocky strata, when they have been made to enter as it were into the solid frame-work of the globe itself, they must nevertheless eventually perish, for every year some portion of the Earth's crust is shattered by earthquakes or melted by volcanic fire, or ground to dust by the moving waters on the surface. 'The river of Lethe,' as Bacon eloquently remarks, 'runneth as well above ground as below.' "

This last paragraph evinces a reluctance to surrender the position which he maintains throughout his work. It is a decided argument in favour of the existence of a continuous improvement of the general organic system, that the most perfect animal should have been the most modern formation. Mr. Lyell is too acute a reasoner not to perceive, that the new and sudden appearance of a species, if it be proved in any one case, must be in opposition to his leading principle ; but neither he nor M. Boué venture to dispute that proposition as regards man. They are also both too well versed in general science, to insist upon the *previous perpetuity* of any species; every astronomical hypothesis, in connection with geology, militates against such an assumption.

Now it is evident, that if new species were suddenly developed at any period, there must either have been some sort of systematic regularity in the order of production, or there must have been none; but they both attribute to the immediate cause or causes of the creation of each species a much greater and more unusual power of production, if they imagine that there is not that inherent capability in the specific series of individuals to improve in organisation, during successive generations, which is only a part of the general progression existing throughout Nature. Mr. Lyell rejects that doctrine; but M. Boué supposes, that during the present epoch, the lowest animal forms only, are generated by inorganic forces, which supposition is perfectly in harmony with Lamarck's hypothesis.

Mr. Lyell's remarks upon the shortness of the historical period during which recorded observations can have been made, are so valid against the arguments of Cuvier, where that illustrious French naturalist opposes to the theory of the gradual transmutation of form, the observations of only four or five thousand years at most,—that it is unnecessary to insist further upon that point: but when we couple those remarks with his own admission, that man is the most modern animal,—with the almost universal geological opinion, that there has been a progression from the simple to the compound, as regards both animals and vegetables,—with his belief, and that of M. Boué, that there have been such new appearances as that of the human race,—and with the observations about those changes in the form of some species, which create varieties, even within a century or two,—we are compelled to admit, that the theory of Lamarck seems the best supported, and the most consistent in itself, of all that have hitherto been published.

All the deductions from the observations which have been made upon *mule* races of animals and vegetables, only establish these facts;—namely, that unless the parents nearly resemble each other, *hybrids* cannot be produced; and that even when such unions are prolific, the offspring is usually, but not always, barren. But such facts are in harmony with the restrictive laws of Nature, which do not admit of an interference beyond certain limits with the *gradual* progressive tendency to change. The general principle of generation is, that the specific form is only to be altered by almost imperceptible degrees, and that the generating power, where there are distinct sexes, is to be mutually participated in by two individuals, as nearly resembling each other as is compatible with the difference of their sexes; the original and first manifestation of the power of reproduction belonging to single individuals, where there is no difference of sexes, as happens in the cases of the lowest animals, and of most plants.

But the very existence of *mules* is evidence in favour of the difference between species being one of degree; the mutual generating sympathy not being altogether destroyed, until the difference is very decided, and until their respective distances from their common ancestral type, points to a much longer interval than the few thousand years to which any human tradition refers. Where the difference between its parents is less decided, the reproductive faculty is lost in the offspring, as may be expected; but where the difference is still greater, there is no such offspring, the object being to hinder the creation of a form which was not intended by the Divine Intelligence to be developed under such circumstances. The whole argument supports the notion of a progressive ramifying development, because some mules produced by parents between whom the specific difference is slight, are themselves productive; and it is a justifiable inference, that the divergent tendency which promoted that difference, was developed at a comparatively modern period.

Every terrestrial body composed of atoms must have a fixed and definite form, and every change which occurs within it must be the result of the changes of relation between its constituent molecules, or between them and molecules which belong to other bodies. Such changes take place ultimately *at some definite moment*, because it is one of the conditions of material changes, that they should be decided and distinguishable at least by inference. Thus the whole process of the growth of an animal, or vegetable, (although the period is not *visibly* broken into the ultimate divisions of time, during which its minute atomic changes occur, because these specific acts are not capable of being appreciated by our observation), is a great system of activity, having its beginning as a whole, but made up of systems within systems, each of which has also had its own beginning. Some of these subordinate systems are developed at one period of its existence, some at another; and one may be replaced by another during the activity of the general system, in a manner so harmonious, that their respective commencements and ends may be imperceptible; but the apparent melting of one process into another in most physiological changes which occur during the life of a plant or animal, leads to the erroneous conclusion, that there is no such decided and defined beginning and end of the subordinate processes.

The same semblance of *indefinite* affinity is offered to our imagination, when we meditate upon the succession of the individuals which maintain the specific series. The prolific plant or animal begets its offspring; and that offspring in its turn produces the next generation, in an apparently unbroken continuity of action: but in this instance we can appreciate the beginning of the subordinate process, because there is a distinct and special physiological act which marks the limit. This is still more clearly defined, when the mechanical separation occurs at the moment of birth, if the child is not separated from its mother until it is perfect, or when the egg is laid by an oviparous animal; or when the processes of reproduction by gemmation, or scission, cause the disjunction of the parent and the offspring in the lowest animals. If La Place's astronomical hypothesis about the origin of the heavenly bodies be correct, the disjunction in that instance, must be a process which has its clearly defined beginning and end; although even then it is a process of a subordinate character, in reference to the whole solar system.

Hence we find, that throughout Nature there is evidence in favour of the whole scheme of activity being made up of subordinate processes, which are like orders, genera, and species of a class, each process being distinct *in relation to a period of time*, however short that period may be. Still there is always a maintenance of continuity in the activity, as regards the whole scheme, which is manifested in the distinct successive phenomena of those separate systems, which are its subordinates; and this implies the *universal prevalence of intervals*. Our atomic theory supposes, indeed, that the first comprehensible manifestation of motion is not only strictly limited *as to space*, but accompanied by intervals of activity and quiescence, succeeding each other with such a rapidity, that there are several hundred billions of intervals within the short period of a second;

so that every jerk or throb of the reciprocating polar forces in each atom, may have an appreciable duration, and therefore manifest a definite beginning and end, *in relation to time.*

Now if we apply these considerations to the subject before us, it seems contrary to the whole scheme of Nature,—when there is such a general and pervading tendency to change, throughout her great system, and when the manifestations of all activity may occur during such short periods,—that a *specific* series in the zoological, or vegetable world, should continue unchanged, as to organic forms and qualities.

Every moment of the existence of an individual plant, or animal, is marked by some organic change during its stages of growth, maturity, and decay; each change being reducible to definite subordinate changes in the relations of the molecules which compose its body. Geology demonstrates, that the genera, orders, and classes of organic beings are constantly succeeding each other; and most geologists admit, that the change is from the simple to the complicated. The analogy between terrestrial organic bodies and celestial bodies, is therefore equally in favour of a continuously improving development of animal faculties. Is it probable, that a *specific* series of plants or animals, is the only stationary system?

On the contrary, is it not more likely, that improvement occurs here as it does in the vegetables, which, generation after generation, have undergone the artificial process of cultivation, during a few thousand years, until their forms are completely altered, because Nature's more slow proceeding has been interfered with by man, in pursuance however of the beneficent intentions of a Providence which destined them for our nourishment?

The hypothesis, that a new creation was necessary to the manifestation of every new species, is in direct opposition to the principle, that all natural processes are brought about by a gradual development of forces, according to the most regular and well connected plan of continuous cause and effect. Each species is a distinct system, and so undoubtedly is each variety or individual of the species. It is true, that every individual must die sooner or later, and the same destiny of dissolution awaits every other body celestial or terrestrial: but the species *is a system, not a body;* and the death of the parent animal does not interfere with the maintenance of the series, in which its offspring become its substitute.

Much reliance has been placed upon the fact of the great differences between the fossil remains in layers of the Earth's surface, which are near each other; and many geologists have inferred, that their observations upon this point warrant the conclusion that there must have been a new creation. But do they take into account all the accidents which might have suddenly destroyed the vegetable and animal inhabitants of the region in question,—the length of time which may have intervened, before it was again inhabited,—the geographical difficulties which may have isolated that region during intervals of perhaps many thousand centuries,—and other circumstances, which may have kept it uninhabited, until a new irruption of the sea, or a new uprising of the land, may have again rendered it an unfit abode for the animals whose remains they expected to find in the layer in question?

On the other hand, the observations made upon successive strata, where the interruption has been less decided, exhibit the commencement and the end of the prevalence of a peculiar form; the gradual melting, as it were, of one form into another in consequence of a succession of such unimportant changes, that the remains would be called those of varieties of *existing* species, (more especially as regards the testacea) offer decided evidence in support of the theory of a progressive improvement and change in the members of the same series. The progressive increase of the number of species, alluded to by Mr. Murchison, and the comparative paucity and general distribution of species in the strata of the older geological periods, are important facts bearing upon the question now under consideration.

Now viewing all that has been advanced by modern geologists, who admit that the progression does tend constantly towards a more complicated and higher order of organic formation,—by naturalists, who lay before us charts, tables, and schemes, of a regularly ascending or descending system of *existing* animals and vegetables,—by astronomers, who, like La Place, assume, that the heavenly bodies are subject to laws, which occasion their consolidation, disjunction, and gradual change from a gaseous or liquid state, into one, which makes them fit abodes for such beings as inhabit the surface of this Earth,—by chemists, who analyse various vegetable and animal substances, and logically infer, that their simple elementary particles must have existed in a less complicated connexion, when the Earth was not habitable by organic beings,—regarding all these considerations, it would be doing violence to reason, to suppose that a new creation of each species was to be inferred from the fact, that species exist or have existed upon the Earth, which offer evidence of a systematic and progressive development of animal or vegetable forms.

M. Boué's assumptions, that circumstances which were formerly adequate to the sudden development of such a complicated organisation as that of a human being, are inoperative now, and that the lowest zoophytical animals, only, are created in that mode at present,—are the strongest arguments in favour of the only *aboriginal* development of an organic system being that of the lowest and least complicated animal or vegetable. Nor does it at all militate against the general theory of a continuous and progressive *spontaneous* improvement of an animal series, that it should contain in itself, from the beginning of its existence as a system, the germs of all those peculiarities, (faculties, instincts and reason, depending on organic structure) which are to be developed by degrees during a long course of innumerable ages. Such a *potential* quality, in the simplest animal form, is in itself not more wonderful, than that of the egg, which contains the rudiments of the splendid peacock's plumage,—or of the bulb which *every year* puts forth the brilliant flowers of a tulip or a lily, although, during the winter, its presence in the garden is not indicated by the appearance of a single leaf.

Every organic being is exposed to accidents, which may destroy it and all prospects of its progeny, and thus annihilate the series in that direction. Vast geological changes may sweep off many, if not all, the existing vegetables and animals of any given district on the surface of a planet: let us even assume, that an entire heavenly body may undergo a catastrophe which would destroy all its inhabitants, for such an occurrence is possible; and such events may have happened in districts of this globe. But it seems to be in the order of the great productive system of Nature, that the lowest animals are constantly generated by the aboriginal causes of their appearance; and some of them may be the ancestors of new series, which would advance improvingly, as preceding systems had advanced, until their descendants become equal in zoological rank to the highest animals which they had replaced.

There are districts upon the earth, in which it seems most probable, that this has occurred. The low condition of the aboriginal inhabitants of regions, where immigration from other countries has been prevented by their insulated position, and where the human race with their domesticated dogs, pigs, and poultry, (and rats, the vermin of ships which have touched there), may have been the only superior animals, suggests that an incalculable number of ages must elapse, before the higher sort of animals would appear again in such parts of the world, if they were once destroyed. New Zealand, equalling Great Britain in size, was in this condition, when first discovered by Europeans.

Those marsupial animals, which belonging to the lowest strata, containing the remains of mammifers, (and which seem to have been the species of that family in which the mode of gestation is the least perfect), with some forms which constitute a link between mammifers and oviparous animals, are the present dominant aboriginal races of *mammalia* in Australia.

Geological observations, however, in both these countries, offer the same strata as those of the Asiatic continent: and one of the most reasonable modes of accounting for the absence of the higher animals, is, that the progression was checked at some very remote era by a great catastrophe, while the insulated position of the land in question, hindered immigration from countries which had not been so universally depopulated.

Another hypothesis, however, accounting for the peculiar zoological conditions of Australia, may be advanced on plausible grounds. There is evidence, which suggests that some portions of the earth are better calculated to hasten the progressive development of a species, than others. It has been shown, that mountainous regions have a decided influence upon the variation of the magnetic needle; and it accords with our general hypothesis, that in such regions the cause of the progressive improvement of organic systems, should be more potent, because the reciprocity of the terrestrial and astronomically produced magnetic influences, would be more energetic there, than in low lands, and more especially in low islands.

Hence we may speculate, that mountainous regions are favourable to the rapid advancement of the progression ; and we may be inclined to agree with naturalists, who trace the origin of species to localities of that description, which are regarded in many botanical and zoological theories, as centres of a peculiar Flora, or a peculiar group of animals.

Even as regards the precocity of the human intellect in olden days, in Greece, Southern Italy, and Sicily, where the inhabitants surpassed the rest of our race in every branch of knowledge, although they were only indebted to themselves, if not for the rudiments of science, at least for the glory of having improved upon what they had acquired to a greater extent in a short interval, than has ever been witnessed in other regions of the earth,—we may attribute these superior mental qualities, in great part, to the mountainous character of the country, and to its happy temperature. In so doing, we may make every allowance for the political advantages of their living in small independent states (a circumstance which always elicits talent); for the same advantages in other countries have never occasioned such a development of the human faculties. This subject, however, will lead us far from the question immediately under consideration ; it belongs to a dissertation upon the mental qualities of animated beings.

The doctrine which maintains, that every species has certain unchangeable characters, has been carried out to the extent of insisting upon the notion, that all members of a species descended originally from the same individual, or pair of individuals. Such was the opinion of Linnæus ; and several learned men have defended it with great ability. But it is impossible to admit this postulate, in reference to the vegetable and animal world in general ; it can never be substantiated by observation. Supposing, however, that so far as concerns the existing races of mankind, the doctrine were true, we are only led back by philological enquiries to the time of the deluge; but it does not settle the main question, as to whether all mankind, *before the deluge*, were the offspring of one pair, if it be proved that the survivors, at that time, were limited to one family, including three brothers, who are not said to have married their near relations.

There is one important argument against the proposition. It is almost universally admitted, that nothing tends more to deteriorate a race, than to allow near relations, and more particularly children of the same parents, to cohabit. All persons engaged in rearing cattle and horses, hinder such breeding in and in, as it is termed, when they can do so: the Mosaic and Christian dispensations agree in forbidding the practice, in reference to our own species. The higher the animal, the more likely is such a marriage to ensure a weak and unhealthy progeny; and Nature implants in the mind of the human race an indifference, which acts as a check upon desire between father and daughter, mother and son, or brother and sister, unless the mind be depraved. But it is one of the consequences of the doctrine which insists on all individuals of the same species having originated in a single pair, that although the first pair need not have been related, the second generation must have entirely consisted of brothers and sisters. In the lowest animals, and in the hermaphrodite plants only, is it a condition of the multiplication of the species, that the increase must have been promoted in this manner. This single consideration is stronger as a physiological argument against the doctrine of Linnæus, in regard to the human race, than all the traditional or philological evidence in its favour.

Let us now meditate upon the elementary question involved in the general consideration of our subject—namely

—the development of the *first* corporeal systems, which were the ancestors of any given species of vegetables and animals.

When the question of sudden physiological innovation is reduced to its first terms, all geological naturalists are its supporters; because the *new creations* of distinct species can only be phenomena of that description which have occurred at certain epochs, if *that* be the mode in which such new species were introduced ; while on the other hand, the first individuals of a *series* must have been originally formed without the intervention of any organic parent, if there be truth in the doctrine of a progressive improvement of the same series having been the cause of the complicated organization of the more perfect vegetables and animals. According to both schools, the physical condition of this planet was such, that *no organised beings could have been its inhabitants at some early period of its existence.*

It is evident, therefore, that those who maintain the doctrine of a progressive improvement of a series, have adopted an hypothesis which is more in conformity with the every-day phenomena of nature, than those who hold the opposite opinion, which is not justified by observation; for they, who believe that the sudden transformation of inorganic elements into so perfect and complicated a system as that of a human body, speculate upon a possibility, in support of which there is not the most remote analogical evidence ; but the universal appearance of *infusoria* of the lowest class, and of *intestinal worms*, under circumstances hostile to the supposition that they could have been produced by beings like themselves, offers direct evidence in favour of the theory of spontaneous generation.

Upon this subject, the opinions of Lamarck, who has written the most extensively upon the theory of the progressive improvement of a series, are more consistent with a general scheme than those of Tiedemann; both these naturalists believe in an original spontaneous development of organic forms; but Tiedemann attributes the organic energy to the *inherent* force of a peculiar sort of matter, while Lamarck refers it to a progressive development of forces in matter which had been *previously inorganic.*

If we reflect on the difference between them, we find that it arises out of the reluctance of Tiedemann to extend his inquiries beyond a certain limit. Had he commenced with the astronomical hypothesis of La Place, he would have found a great difficulty in persuading himself, that one sort of matter in the nebulous Sun, when the size of that heavenly body equalled that of the orbit of Saturn, was *potentially* organic, while another sort was to remain for ever in an inorganic condition. It is much more in harmony with the general principles of one great scheme, to suppose that the progressive improvement is only one of *forces* or *tendencies,* which are gradually developed in *all* material substance, according to circumstances, when the first process of formation, that of the atom itself, has taken place.

The doctrine of those who believe, that every species is an aboriginal creation—is more consistent than that of Tiedemann—because, if it be once admitted, that the special qualities of matter are *absolute*, there may have been one sort of substance originally set aside for one species, and one for another; and this notion is that of Bonnet, who supposed that the *corporeal* or *material germs* of all prospective organic beings, have been in existence " from the beginning." Bonnet's psychology is really a system of materialism.

But if we believe, that the germs of all physical systems are the *potential* qualities of *incorporeal* forces, we are at once led back in our analysis to the first development of material form, and to the *individualisation* of a distinct portion of the homogeneous material ether, and consequently to *the beginning of the formal world*, so far as regards that region of infinite space, which can be observed by the astronomer.

Tiedemann is decidedly of opinion that there is as marked a distinction between the organisation of the lowest vegetables and animals, as there is between inorganic and organic bodies; although in the lowest forms it is difficult to determine the distinction. Lamarck says, animals are *irritable*, but denies that plants have that property. Undoubtedly the distinguishing feature of an animal body is its attribute of a nervous system; but this may exist under such a mode of arrangement as to be altogether beyond the reach of our direct observation, and oblige us to infer from the effects, that one organic body is animated, while another is not endued with the principle of *sensation*. Tiedemann, however, lays it down as a maxim; "that as regards the chemical operation which accompanies life in both sorts of organic body, there is a continuous process of *disacidification* and a continuous production of combustibles in the vegetable; while in the animal there is an oxidising process which occasions a sort of combustion."

This distinction would be very important in a physical sense, if it could be applied to the lowest animals and vegetables. The differences between the highest sort of plants and all animals, except some of those beings which are called zoophytes, are clear and decided; and if it were not for the existence of such paradoxical creatures, there would be no doubt upon the subject. We must, however, bear in mind, that according to the general rules of a progressive system, *animated* life ought to have been first developed in its most simple mode of manifestation. What that *simplest* mode is, we may never know: but that it involves the phenomena of some *obscure sort of sensation*, is a justifiable inference; and this faculty is denied to the most complicated and perfect vegetable. The question at issue is really one of metaphysics, for with the exception of Tiedemann's chemical test, (and that may not be available in some doubtful cases) we have no decided criterion: *locomotion* may not be the property of some animals; and although it is proved by microscopic observation, that many of those very minute animals which are grouped together as *infusoria*, have stomachs, and are nourished by fluids taken into that cavity, while all plants are nourished by absorption,—still external matter may be absorbed cutaneously, and thereby incorporated in animal systems, even as regards those of a higher grade of animals.

Again in many organic bodies, of whose animality there can be no doubt, there is no visible trace of a nervous system; but this does not preclude us from firmly believing, that they contain some material substance which answers the purpose of distinct nerves, although that substance may be undistinguishable by our powers of observation from the rest of the body. The whole argument, therefore, favours the opinion, that all animals differ from vegetables, in possessing *the animating principle*, but that, as the improving progression of the series advances, new material organs are developed, which first demonstrate the existence of that principle, because we observe the organs through which it acts, and is acted upon.

Nevertheless, there is every ground for the faith of the devout psychologist, that the perceiving, thinking soul, the "moi" of Cuvier, or the principle to which we allude,—is a really existing being, wholly independent of the action of the material body which it animates, and that its *special individuality is the same, whatever may be the mental organs or nervous material instruments of its intercourse with the atomic world.* In this respect it seems to be the metaphysical counterpart of the aboriginal, physically unaccountable, and incorporeal dual force, which, according to our theory, generated the atom itself. The only proof of the soul's existence is to be found in the simple *sentiment* of "being," which sentiment is *obvious* to one person and one only, the individual who feels it. That other animals are animated is but an inference, although an inference of the highest order.

The distinction, therefore, between animals and vegetables, as to their origin, is very important, because we stand in need of a different organisation, when such a faculty as that of the lowest imaginable *sensation* is to be produced. Vegetables, so far as their want of this faculty is concerned, are vastly inferior to animals. But life or vitality is a process common to both classes of organic beings.

Let us now consider the phenomena connected with the development of entozoa and parasitical bodies; for they suggest some of the strongest arguments in support of the theory of spontaneous generation.

SECTION XVII.

On the development of parasitical and intestinal organic bodies.

THE general hypothesis about the reciprocity between magnetic bodies being the stimulating cause of the development of organic life, is supported by the phenomena of parasitical plants and animals.

Most species of vegetables and animals are liable to be infested by more than one species of parasite, which is itself capable of reproducing offspring, although the first appearance of the series is sometimes quite unaccountable; and the extraordinary circumstance connected with this branch of zoology is, that certain parasites only appear upon a certain plant or animal, while the appearance is further limited by certain parts of the body being infested by their own special varieties of the same sort of parasite.

Two species of louse are found on man ; one of these is confined to the head, the other to other parts of his body : and children are most afflicted with the first, while elderly people suffer from the presence of the other, which occasions *phthiriasis*, one of the most formidable and disgusting diseases that can assail our race.

There is no mammifer or bird exempt from this annoyance. Fishes suffer seriously from it. Some insects, more especially the larger species of beetle, swarm with parasites peculiar to their race, and even those insects which are microscopic, will be found, under high magnifying powers, to be the prey of this disease.

When we reflect on the whole course of argument adopted in our essay, the production of parasitical plants and animals seems to be the necessary consequence of the general prevalence of certain laws ; and it offers corroborative evidence in favour of the doctrine of progression. Parasitical insects infesting vertebrated animals, are of a higher order than those infusoria which we have supposed may be the progenitors of the most complicated animated forms of this globe ; and this assumption might seem to militate against the theory, because *pediculi* and *acari* must have been generated spontaneously, as it is termed, instead of deriving their origin from less complicated organic forms. But the fact of their occupying a higher place in the animal scale is really in harmony with the uniformity of the whole scheme.

We have already supposed it to be a general law of Nature, that every distinct aggregate of atomic matter, is a magnet or magnetic system, capable of reciprocating with other magnetic bodies, and of thereby influencing the matter on their respective surfaces in such a manner, as to occasion the development of some new arrangement of the particles, corpuscules, or other portions of those surfaces. The formation of organic bodies has been attributed to such a reciprocity of magnetic influence between this Earth and the Sun or Moon. Now it is only following out this doctrine, to attribute to each organic body so formed, a faculty of reciprocating magnetically with the Earth, Sun, or Moon, and of causing a new arrangement of the particles of or upon its own surface; and as every vegetable or animal in question is a higher or more complicated system than any aggregate of inorganic matter, the inference would be that the new production should be itself a more complicated system, than the original organic body produced by the magnetic reciprocity of two inorganic masses, —whether such masses were the Earth and the Sun, or the Earth and Moon, with its reflected magnetism.

Such a doctrine may appear the more startling, when it is remembered that according to the general theory of progression, the highest animal now on the Earth's surface must have derived its own ancestral origin from a lower or more simple organic form, than the parasite, which spontaneously burst into life upon its own body; but humiliating to our pride as this inference may appear to some, and absurd as it will undoubtedly be pronounced to be by others, it is an induction supported by the fact of man being the prey of animals with which he will be infested, if he neglects those acts of cleanliness which are enjoined by the oldest religious rites of antiquity, and by the practices of all civilised nations. It is not one of the least important results of civilisation, that as by constant care and attention we may in most instances free ourselves from these inconvenient accompaniments of inorganic matter attached to our persons, it should be considered shameful to allow them to be formed in consequence of our not removing the sort of dirt with which the skin of most savages is begrimed.

The law of nature, which forces us to be, unwillingly, the parents of vermin, is capable of being explained by meditation upon the continuous energy of the magnetic force, if we once admit that such an energy is a stimulating cause of organic development. The pediculi and acari appear to hold the same relation to higher organic bodies capable of producing them, as that which the most simple infusoria hold to the surface of the earth; and it seems probable, that the comparative complication of the parasite's organisation is in a general degree proportioned to that of the animal which it infests.

Again, as regards vegetables, we may infer from observation, that there is a reciprocity between the terrestrial magnetic force and their own, which has a powerful influence in modifying the forms of certain animals which feed on their juices; but as the lowest plant is *physiologically* a more exalted system of complicated relations than a heavenly body is, it is possible that the reciprocity between plants and the Earth may promote the development of animal forms. At all events, we are justified in assuming that vegetable parasites may be thus developed in the first instance, although, like the pediculi, they have the generative faculty of reproduction.

The remark of Oviedo, that in certain equatorial regions of the Earth vermin of this description cease to infest sailors (a remark, however, which requires confirmation), may corroborate our general magnetic hypothesis, and tally with the observations of experienced navigators upon the variation of the intensity of the ordinary terrestrial magnetic force, which is weakest on the equator. But Oviedo's remark may apply to that meridian in the Atlantic, where the great circle of no variation cuts the equator; for there would not only be a weaker magnetic influence generally at that point, as being farthest from the poles of the Earth, but a nullity of any magnetic influence as regards the internal terrestrial nucleus of this globe.

Now, should it be proved that Oviedo is correct about the whole equatorial region, we are warranted in assuming that the production, and perhaps the existence, of these parasites depends upon a reciprocity between the magnetic currents on a human body and those of the Earth,—the tendency to develope them increasing or diminishing with the relative intensity of the terrestrial magnetic forces on any given latitude. On the other hand, should it be found that the phenomenon only occurs on that part of the equator where there is no variation of the compass,—in other words, where the *minor* terrestrial magnetic force of the Earth's surface replaces the *major* force of its internal nucleus—the fact is confirmatory of our hypothesis. It may indeed be possible that wherever there is no variation of the compass, the development of parasites may be unimportant, if not absolutely null in every latitude : observations in America and Australia would decide that question.

But as it is assumed, that the reciprocity depends upon the joint influence of two magnetic bodies in this as in every other instance, the variation of the magnetic force of the animal body, which generates the parasite, must be taken into account, as well as that of the Earth. Not only are children peculiarly liable to be afflicted with worms in the intestines, and by lice on the head, but calves are subject to ringworms in the head, and lambs have lice in the same region, which are not common to these genera when full grown. The pediculus found on the body of a person advanced in life, must owe its origin to some cause connected with his having passed the period of adolescence or maturity.

With such data, we are induced to suppose that there is some magnetic force *in the child* which acts *internally* as regards its body, and *externally* upon its head ; but that a change in this respect accompanies its growth, and is complete after a certain time of its life, when the intestinal worms incident to childhood, generally cease to appear, and the external development of parasites is no longer principally confined to the head of the human body.

May we not speculate upon a greater organic energy existing in the *growing* person than in the mature man? All the processes of nature are more rapid as regards the conversion of food into a portion of the animal body at that period. The brain advances with a rapidity which can only be appreciated by our consideration of the very early attainment of mental powers observable in children, and of their acquiring the rudiments of language; not merely being able to call perceptible objects by their right names, but to catch the terms of abstract ideas and sentiments almost as soon as they can speak,—a faculty which is manifested much more slowly afterwards, in learning new languages, even when such sentiments are connected in their minds with words of their native tongue.

Anatomists find the brain at the seventh or eighth year of life as large as it will ever be; a most important fact in relation to the faculties of the child, and leading to the inference that although its structure improves afterwards, the *cerebrum* increases more rapidly during those first few years than any other part of the body does. Here then is a cause of magnetic energy adequate to the occasion; and it should be remembered, that the cerebrum is peculiarly the organ which develops magnetism in its most transcendent character, because there is no result of physiological action so elevated as that which generates ideas.

Thus, independently of the general superiority of the organic force in a growing child over that of a person who has ceased to grow, there is a special distinction as regards the growth of that internal portion of its body, outside which the parasitical animal peculiarly observed in children, is believed to be formed according to the laws of *heterogenesis.* The same mode of reasoning is applicable in a minor degree to the production of worms in the child's intestinal canal.

Again, when we search for the cause of the general development of the other sort of pediculus, rarely found on children, and if found on them, always to be accounted for by their having been in contact with elderly persons so affected,—we may speculate upon an opposite cause, *the diminution of the vital force.* All organic bodies are liable to be the prey of parasites, when they grow old. Trees suffer in this way as well as animals; and when either the plant or animal is enfeebled by disease, the maladies of this description become more serious. An inferior nourishment of mature organic forms will also produce them, or render such bodies subject to an invasion of mosses, lichens, acari, and pediculi, which are generated elsewhere. The same may be observed as regards portions of a dead body or a dead tree; and many animal productions, such as decomposing cheese, soon swarm with tribes of living creatures.

Hence it appears, that in this process there is a manifestation of a general natural energy, incidental to the comparative force of the vital force in every animal and vegetable form of matter;—that the pediculus, for instance, is generated spontaneously by the human body, when that body is *positively* magnetic in relation to the Earth, as well as when it is *negatively* so;—that during the period of maturity there may be a balance between these two opposite conditions of the relation, when the parasite-producing energy is entirely or almost inert;—that there is a specific difference between the pediculus of the head and that of other parts of the body;—and that we find in this explanation of the phenomena, a confirmation of the general hypothesis, that in every case of spontaneous generation, the fixed starting point of the new progression depends upon the stage of the original progression already attained by the vegetable or animal which generates the parasite in question.

The prevalence of the tendency in *living* bodies, whether they be vegetable or animal, to produce parasites, is not so evidently useful (as part of the general scheme of the organic world) as when the same process occurs in the decomposing substances of portions of a dead body, or in animal or vegetable excrementitious matter; for then, *useless* organic substance is rendered available in the great laboratory of vital operations, and new series of organic beings are thereby introduced into the world. But such occurrences take place in accordance with general laws, to which all organic bodies are subject. Peculiar generative forces, which are only active under certain conditions, must be developed in obedience to a higher system, than that of any animal. The *positive* intensity of the magnetism of the *growing* body (in the case of the child) in relation to that of the Earth, may elicit the parasitical development at that moment, while the relatively *negative* state of that of the *declining* body of the old man may promote an analogous phenomenon at a later period of life. The convenience or inconvenience of the human creature is disregarded by Nature, when such considerations might interfere with her general rules.

The climax of *convenience* to any individual of the human race, thus subject to the laws of *heterogenesis*, is the middle period of his life; the child must undergo the annoyance in a minor degree, and is less under its influence, as he approaches maturity. The old man, on the contrary, in this as in all other diseases, is again brought into subjection to physical causes of *decay*, which assail organic structures in obedience to the general operation of natural agents, when the complicated energy of his vital powers begins to give way; and he is thus forewarned of the approach of a period when the system of his own body will be used by an unerring Providence as the medium of development of a new and lower order of organic beings, some of whose remote descendants may be gradually advanced, at last, to a specific form as perfect as his own.

Still, although the organic matter of higher animals during their lives is brought under subjection to the laws which develop lower animals; there may be a new starting point, as regards the development of the parasite which is called into existence by their influence. The pediculi and fungi, which may be produced by *heterogenesis*, are higher organic beings than the lower sorts of infusoria and byssi, from which the higher animals themselves may have descended, through a succession of innumerable generations.

Such a scheme of organisation is perfectly harmonious, when we remember that every animal capable of having sentiments or perceptions, may be the parent of three distinct classes of objects,—the *parasites*, which it develops unconsciously and automatically; *the progeny*, in which the maintenance of *its own species* is ensured; and the *ideas* which are created by its mental powers.

As regards the first class, there is an analogy between the Earth and the vegetable or animal which produces the parasite: if a reciprocity between two heavenly bodies be necessary to the development of any organic system of either of these heavenly bodies,—a similar relation between an *organic* body and the Earth may promote that of the parasite. This, however, is a more complicated operation: the animal thus called into life is of a higher class than that produced by the reciprocity between two *inorganic* bodies; one of the reciprocating aggregates is itself an *organic* system. Still the process would be completely physical in both cases.

The second class of generative phenomena is intimately connected with it, when the reproduction of the species takes place by scission or gemmation, and the parent body gives birth to animals nearly resembling itself, by being divided into parts, or developing and throwing off young ones from the surface of its body, as shoots are sent forth from the growing tree. Observations enable us to trace up the improvement of the generative process through all the various changes of method, which appear in the zoological system. If our series of observations be made in the descending direction, we find that each lower grade of animal has a faculty of reproduction, which denotes an increasing simplicity of process, until those of scission and gemmation appear to be as mechanical as that of spontaneous generation itself.

The mental creation of *ideas* in the animal mind, may, in like manner, be said to hold an analogy to the vital process of maintaining the specific series, or to the gradual development of organs in the embryo, and *growing* organic being after its birth; and if we believe that the growth of the organs of the nervous system is connected with a magnetic influence of the *reflected* solar rays, we find the analogy complete. The reciprocities between inorganic portions of the *same* heavenly body,—between *two* heavenly bodies,—and between *three* heavenly bodies, through the instrumentality of such an operation as lunar reflection,—seem to hold the relations of causes to the effects of *chemical*, of *vital*, and of *phrenological* activities respectively, as regards aggregates of matter upon the surface of the Earth. The progressive improvement in the development of the great magnetic scheme coincides with the progression of every animal function, including that of reproduction itself.

Finally, we may remark, that vegetables were obviously made for the convenience of animals; but that unless we search for some ulterior object which is more important than the existence of lower animals, the unity of the great scheme of Nature will appear broken. As a member of an *unchanging* specific series, an earthworm is but a sad type of animality; and the precarious existence of most of the lower animals carries with it no object of future interest;—the rapine and cruelty which pervade the whole animal world, might at first lead us to suppose that a capricious demon had disported himself in the work of animal creation, not that Divine beneficence had applied the abstract truths of physics to a great end, worthy of its own transcendent mind.

But when we believe that the existence of the lowest animal is a *necessary* stage in the development of a continuously improving animal series, and that in accordance with the unerring progression of those physical conditions, *to which, for some reason beyond our comprehension, the entire animal world is subject,* the manifestation of the higher animals must be preceded by that of the lowest, in order that such incorporeal ideas as those of human reason should be made manifest,—we discover an argument in favour of the doctrine, that the corporeal form of every animal embodies a manifestation of an improving system, both as regards the whole series, and the individual. The most highly-gifted human philosopher must individually have gone through the gradual changes of an embryo state, of infancy, of childhood, and of adolescence: and such a progressive improvement of the individual, which no one can gainsay, may hold an analogy to the gradual improvement of a specific series. Where it is to end, and when the series is to terminate, we know not; but the analogy suggests that every animal, whatever may be its grade in the ascending scale, is a physical instrument in the great plan, *having for its ultimate object some glorious manifestation of mind, even when mind is still dependent upon material organisation.*

That the animal series is fated to end at last, is an inference deducible, according to the strictest rules of logic, from the almost universally-admitted postulate, that as regards every animated creature on this globe, it must have had a beginning ; but that man is the highest possible animal, or the *ne plus ultra* of material organisation, would be too bold a speculation for any naturalist. In many respects we are but mechanical agents in the vast plan of Nature,—exposed, it is true, to less suffering than other animals, but still exposed to suffering, in consequence of the prevalence of physical laws. Our bodies are not formed for the purpose of our being murdered and then devoured, as almost every individual of a domestic race of animals is by ourselves ; but we are often the victims of injustice and oppression, of physical violence and misery, in consequence of the injustice of our fellow-men.

Still the progression gradually tends to improvement in these, as well as in all other respects. The social institutions of civilization have gradually lessened the suffering of the mass of mankind : although in this instance there is an occasional retrogression, as the pages of history will show, the secular improvement of the human race has been sometimes retarded, but it has never been wholly checked. Tradition preserves the account of two great periods of degradation : it seems probable that the ancient Egyptians, or Chaldeans, were in possession of knowledge which can only be traced to certain opinions, that survived the scientific methods by which they were attained. No recorded astronomical schemes will account for their nearly knowing the precise distance between the Earth and the Moon ; yet the doctrine upon that subject handed down to us by the Greeks, and borrowed from the East, is wonderfully correct. Why science declined in the earliest periods, is not mentioned in history : the Chaldeans and Egyptians may have only retained astronomical traditions, which were preserved when the deluge overwhelmed the countries from which the founders of those nations originally came. Scientific men may have been destroyed by that catastrophe; but physical truths, which had become popular opinions, may have been preserved in the recollection of those who were less learned. Other causes of the decline of science may have prevailed, during a subsequent period.

Again, the Greeks obtained a high position in philosophy, and their histories enable us to trace their rapid advance in knowledge; but the destruction of the Roman Empire, and the inroads of the barbarians of the North, will account for the existence of the dark ages, as they are most appropriately termed. We are living in a third stage of scientific improvement, and our successors may be exposed to the retrogressive influence of some physical, political, or moral cause of deterioration in this respect. But the *secular* continuousness of the mean advance of human knowledge has always been in operation, notwithstanding these alternations and retarding circumstances. Some information obtained by philosophical meditation has always survived such catastrophes, and afforded a new and advanced starting point for the philosophers of future ages.

In concluding the dissertation upon the origin of species it is necessary to repeat that questions of a theological character have been carefully avoided, and that all surmises about pure psychology have been purposely kept out of this essay on physics. The existence of an *animating principle*, or of an individual *personal* basis of sensation in each animal, has been assumed as a postulate, in the same way as that of an aboriginal homogeneous material substance, or of the individual forces which give it forms and qualities, have been. Yet, we may assume without further argument, that there is some future compensation to each individual animal, in the great scheme of Nature, for the service which it performs, and for the suffering which it must undergo, in consequence of its subjection to the physical laws of that system,—where the misery of one animal is necessary to the nourishment and pleasure of another, and where the general plan of the improvement of man himself is amenable to conditions, which apportioned fewer advantages to those of his own species, who existed in earlier ages than to the majority of the inhabitants of the civilised world at present.

Physically considered, every animal, man included, is a mere instrument in the hands of Nature, destined to keep up and improve the great series of Beings, of which he is a constituent member; and as each individual is liable to destruction, not only as regards himself, but with respect to the future prospect of having any offspring (for infants *must*, and mature animals *may*, die without progeny), this attention to the general principle is so arranged, that the suffering of each animal may be of no advantage to himself, or the maintenance of the species. The annihilation of an individual may be that of a series; and out of millions of lower animals which are called into being, by *heterogenesis* or *homogenesis*, one being only may contribute to the maintenance of the great system of continuous improvement.

Hence it follows, that in reference to physical laws, there is a providential calculation of what we call chances, which does not take into account the interests of the individual, but treats it, as if its body were a mere chemical aggregate, when the great object of progression is in contemplation. That object may undoubtedly be, and we believe it is, the future manifestation of corporeal individuality under such conditions of phrenological power, and social advantages, that the end may seem to justify the means. Still, in the mode of attaining this end, there is a disregard for the suffering of animals, which is at variance with our purest notions of benevolence, although scientific economists may endeavour to apologise for it by alleging general convenience as a justification. Natural religion, however, inculcates different doctrines; and our instincts of charity and kindness rebel against such a justification.

The paradox is only to be explained by the supposition, that the passing physical world of subserviency to material laws, is not the only world; and that whatever be their temporary and passing state of being *here*, all *animating* principles belong to the same immortal category of essences, as those incorporeal forces of Nature, and that homogeneous ethereal matter, which are *aboriginal* elements in our physical scheme.

SECTION XVIII.

General remarks on Phrenology and Animal Magnetism.

The two popular branches of physiological science, under which all the mental faculties may be considered, are phrenology and animal magnetism: both are divisions of the same general class, and they are so connected, that a critical examination of the one involves that of the other.

The study both of human and comparative physiology induces the opinion, that the origin of the nervous forces of animals is to be found in three distinct sets of organs, —those of the sympathetic nerves in which the ganglionic system prevails,—those of the spinal chord and its appurtenances, some of which are also ganglionic,—and those of cerebrum and cerebellum.

The ganglionic centres of the sympathetic system,—the whole spinal chord,—and the brain, generally consist of two distinct sorts of substances. The sort which is always internal, has a white appearance, and the other, which is cortical or external, is of a grey colour. Most physiologists look upon the grey substance as the seat or originating mainspring of the nervous force, and the white as the matter which conducts it. Pinel and others affirm, that in cases of *mania*, it is the grey substance which suffers. Since the cerebro-spinal filamentary nerves are almost entirely composed of the white matter, they must be regarded as the conductors, which are instrumental in distributing the nervous influence to various parts of the body, and in keeping up the connexion between those portions of the whole system, in which the grey substance is present. Wherever the *grey* substance is not found, we are justified in assuming that there is no centre of the nervous force, but that the nerve in question is only a medium of connexion. That the external substance of a nervous organ should originate the force itself, is in harmony with the proposition advanced throughout this essay, which assumes, that the magnetic properties of all bodies are developed upon their surfaces. It is also consistent with the opinion, that the various ganglia of the sympathetic system are separate localities of special sorts of the nervous force.

After pointing out how they are placed in the human body, Dr. James Johnstone, in his treatise on sensation, says,—" The whole of the ganglia are thus connected together, as well as with the cerebral and spinal systems, while their nerves are distributed to all the organs of nutrition and generation ;" and he quotes the following words from Muller :—" It is well known that the fasciculi of nervous fibres in the sympathetic nerves, have for the most part a grey aspect, while those of the cerebro-spinal nerves are white, although the latter nerves also contain some grey fasciculi mixed with the white ; and in many parts of the sympathetic nerves there are white fibres mixed with the grey fibres. Remak has seen both white and grey fasciculi in portions of the sympathetic nerve taken from various regions ; the white fasciculi are probably motor and sensitive fibres derived from the cerebro-spinal nerves, while the grey are destined to rule over the organic functions."

This power of "ruling over" or directing the locomotive or gravitating forces of organs, is precisely the attribute which has been assigned in our general hypothesis, to the *magnetic influence* in every stage of its manifestation: a portion of the *mind* of the whole material world is incorporated in the magnetic activity of bodies, be they organic or inorganic; but it is one of the conditions of the atomic system, that the energy of the influence should be localised as an interpolar dual force, which agitates the extreme ethereal envelope of every aggregate of atoms; and this general rule is applicable to each part of the nervous system, in an animal, in which the grey substance makes its appearance,—each separate organ of this description being in reality a distinct magnet.

Every such organic magnet, however, has its own peculiar functions and qualities; some are destined to maintain the vitality, and to promote the growth of the body; some to keep up the specific series, by causing the generation of new bodies; some to give the animal the power of material perception; while others create its various propensities and talents, and *its power of adopting or of generating* IDEAS.

Comparative anatomists have differed about the relations between those animals, in which there is a predominance of the ganglionic, or of the cerebro-spinal system. Some affirm that there is an analogy between the sympathetic system of the vertebrata and the large ganglia of the invertebrated animals; but Muller has observed two distinct systems of ganglionic nerves in insects, one of which he supposes is the representative of a cerebro-spinal apparatus, and this is always found under the viscera, and generally consists of a certain number of large ganglia connected with each other by a double nervous line running from the head towards the tail of the insect between its legs; while the other consists of much smaller constituent portions, and is distributed in the regions of its intestinal canal and other viscera, in a manner analogous to that of the sympathetic system in the vertebrata. In one species of beetle, all the larger ganglia and their double connecting chords are united in a solid continuous form, which bears a decided resemblance to the cerebro-spinal system of vertebrated animals; and this peculiarity offers a transition between the articulated and vertebrated animals, which seems to corroborate Muller's doctrine.

Still it is very doubtful, whether anatomists are justified in calling the upper ganglion of the articulata a distinct cerebral system, or in supposing that the mental faculties of insects are only attributable to the upper portion of the ganglionic series. When compared with the other ganglia, it holds no such predominance over them in regard to size, as the cerebrum does over the spinal chord of the vertebrata, which will warrant the assumption; and it seems more reasonable to suppose, that the powers of the mind are so distributed in the insect, that each ganglion in the subventral line corresponds with a distinct portion of the brain of a vertebrated animal, as well as with its spinal system. This is the more probable, as the intelligence of the bee and ant so far exceeds that of many vertebrata: the nerves of their senses converging to the ganglion in question require a central region in the head, as the place in which their nerves of perception meet: and this locality is not the cerebrum in the lowest animals. The phenomena which follow the decapitation of insects, differ altogether from those which are produced by cutting off the head of a vertebrated animal; but when the whole chain of an insect's larger ganglia is cut through, or a knife is passed between its legs, instantaneous death is the result.

Hence it follows, that if we must look to the entire series of ganglia comprised in this line, for the origin of qualities which are otherwise distributed in vertebrated animals; and if the nervous contents of the head in an insect are specially devoted to its senses, the other large nervous masses or subventral ganglia may at least participate in its mental qualities, because the whole nervous system in this division of animals is one of ganglia. This is a most important conclusion in reference to the development of instinct; since it inculcates the opinion, that the mental apparatus of animals, whose habits are entirely instinctive, is a dispersed sympathetic or ganglionic system.

Physiologists are in error, when they consider each separate instinct as a mere isolated faculty. The complicated mental operations of bees and ants, promote as completely connected a result, as that which is occasioned by the highest reason of man. The political organisation of a bee-hive, or ant's nest, is far superior to any scheme of government which has been imagined, and carried into effect by our own race. Still the whole conduct of the bee or ant is strictly speaking instinctive; the bee's courage and self-devotion to the commonwealth,—its obedience to its prolific queen,—and its abnegation of selfish interest,—are all automatic qualities having one great object, and directed to one great end, the advantage of the social community, to which it belongs. Such animals have reasoning powers, but they are all subservient to the controlling influence of instinct. We cannot, therefore, avoid making a classical distinction between their instinctive intelligence, and the comparatively free exercise of judgment in the vertebrated animals, who are not thus *compelled* to act right, but who *frequently act wrong*, when they follow the dictates of their miscalculating reason.

Hence we may conjecture, that although instinctive reason is found in all animals to a greater or less extent (and man is in some respects always under a sort of spell to obey its dictates), there are grounds for the supposition, that *choice depending on judgment is the faculty of the mind, which holds the opposite relation to instinct*; and that *reason* or intelligence *without liberty of choice* may be most appropriately termed *instinctive intelligence*; but it would be a mistake to suppose, that a *wilful* exercise of the reasoning powers is absolutely superior to intellectual operations of the mind, where there is no freedom of will. The contrary may be the case. The reason of the bee is more unerring than that of the monkey, although the monkey's brain and whole organisation so nearly resemble those of man; and in many respects the bee is a more perfect animal than the monkey.

The automatic impulses which are called instincts are relations to certain parts of the nervous system, which may or may not be situated in the head of an animal. The lobes of the cerebrum in the vertebrata must contain organs specially destined to instinctive impulses which govern their conduct; but such impulses as those which prompt the animal to acts conducing to its own nourishment and the reproduction of its species, are found where there is evidently neither cerebrum nor cerebellum; and we must infer that the ganglia are the centres of force in such cases. It therefore seems probable, that the basis of all instinct is a ganglionic system, which becomes more and more concentrated as the series advances in complication; and that, at first, there is but one general sort of ganglia: in consequence of this organisation, the lower instincts differ but little from the impulses which promote the processes of growth, of the assimilation of food, of the circulation of the nourishing fluids, of the various secretions, of respiration, &c.,—all which processes contribute to the maintenance of the human body in a state of health, without our being conscious of their activity. By degrees, however, certain animal functions become distinct from others, as regards the discriminating power of the Self; and this physiological development of consciousness is proportioned to the distinct separation of the general ganglionic system into two leading classes of ganglia in insects, one class belonging to functions which are of a mental character, the other being connected with those mechanical or quasi-vegetative processes which go on without their being perceived by the self.

Finally, in the cerebro-spinal system, the processes in question are divided into three general classes. The lowest of these, which do not involve consciousness, belong to the ganglionic system properly so called, and the centres of such forces are dispersed throughout the viscera. The second class are found attached to the spinal chord and its appendages, and are subdivided into functions of sensation and motion; those of sensation (which may be called *passive*, since the self receives impressions through them), are the properties of spinal nerves, each of which are interrupted by a ganglion; while those of motion which convey the impulse from the sensorium to the moving organs, may be called *active*, and such nerves are distinguishable by the absence of ganglia. The third class of functions in vertebrata, belong to the cerebrum and the cerebellum, and they include all the instincts peculiar to animals which have no freedom of choice, as well as the reasoning faculties which promote new ideas, and give an animal the faculty of choice depending on judgment.

Hence we may speculate, that in all cases of insects' instinct, and of impressions perceived by the sensorium, the ganglionic system prevails; and since there is so great a resemblance between the phenomena of animal magnetism and those of the collective instinct of an insect, we may expect to find that such phenomena are in some way connected with the difference of an inductive reciprocity acting between animals through the media of those distinct parts of the nervous system which are called ganglia.

Animal magnetism, in the ordinary meaning of the term, conveys the notion of an *external* source of influence upon the mind; and the most ordinary phenomena of such experiments as those which exhibit one person in a state of somnambulism induced by the will of another, belong to this class. There can be no doubt, that this is the manifestation of a *dualism*, in which one person represents power, and the other subjection, or in which one is *positive*, and the other is *negative*; and this is the popular way of considering the relations between the magnetiser and his patient. But when we apply the term more generally, and institute a connexion between instinct and magnetic subserviency, as opposed to choice and independence, we find that the phenomena are manifested in one animal without the intervention of another: the automatic but unerring conduct of the bee or ant, is controlled by its own *inherent* tendencies in the same manner as any ill-judged acts are in a human being. If there be any *external* dualism in this case, it must be promoted by relations between the animal and the paramount incorporeal mind, which prevails throughout the physical world,—a power to which the most *wilful* animal is equally subject. But although this explanation extends the meaning of the word, it does not contradict the assumption, that instinct in such animals may depend upon its having the organs of the mind dispersed in various ganglionic centres.

Hence we are induced to believe,—that throughout the animal series, there is a constant manifestation of an automatic controlling power acting upon the individual through the sympathetic system of its body;—that in the lower animals, and in all insects and other articulated animals, this is as much connected with the peculiarities of their organisation, as the forms of their organs are, and that it is derived from the same physical source;—but that in the vertebrated animals, where there is a development of will proportioned to the structure of the cerebrum, a new system of mental activity becomes apparent, in consequence of the formation of a new sort of organisation (the cerebral system), which is to a greater or less extent independent of the spinal and other ganglia, and of external influences acting upon the sensorium through their instrumentality.

Thus the presence or absence of the cerebrum may have an effect upon the general mental qualities, so far as the development of will is concerned; but it does not follow, that the functions of the mind should be exalted in consequence of this introduction of a new organ into the animal economy. The contrary result is evident in many instances. No practical naturalist would ever place the mind of the bee below that of a fish, although the vertebrata *as a class* are superior to the articulated animals. The progressive improvement of the ganglionic system without a brain, may be continued in one direction, long after the brain has been developed in another; the whole force of the progression may be confined to the ganglia of the insects, and may be productive of higher mental qualities than when the same quantity of inherent magnetic energy is distributed between the cerebro-spinal and the inferior ganglionic systems of the body of a sheep. This parallel variety of development is perfectly in harmony with the general scheme of the continuous improvement of a series; although we are unable to point out the reasons for its being thus varied, unless we adopt a modification of Lamarck's theory.

When complicated instincts and choice resulting from reason are the properties of the same individual, varieties in the mode of their interference with each other, appear to prevail not only in genera of the same order, but in species of the same genus; this can only be demonstrated by the habits of animals. Anatomy will not explain the causes of the very marked differences, which exist between the social nature of the rook and the solitary habits of the raven, or between the different methods of building nests of the jackdaw and of the rook, although they are so much together. Every species has its own peculiar and invariable instinctive customs.

In accordance with the general law of improvement, which has already been traced through so many stages in the magnetic development of the inorganic world, vertebrated animals manifest an increased power in their mental faculties, which is always proportioned to the complication of their organisation. This improvement reaches its highest *known* point in man. But it is one of the great discoveries of the present age, that the superior instinctive powers of the mind in human beings are made manifest during slumber, when persons are in a state of somnabulism, or under the influence of animal magnetism. When they are awake, their reason is only assisted by the senses; but when the ordinary organs of perception are no longer of use in connecting them with the external world, the original instinctive power, which is the only connecting link between the lowest animals and other bodies, is developed in so transcendent a manner, that with the exception of that of sight, the ordinary means of communication are insignificant when compared with the comprehensive faculty of perception in the somnambulist. The evidence as to the fact of this being the case, is so complete, that physiologists are justified in proceeding at once to attempt the solution of the problem.

SECTION XIX.

Hypothesis accounting for the phenomena of Animal Magnetism.

We assume that all the animal functions are promoted by forces emanating from certain nervous centres, which may be called animal magnets, if we consider them as physical agents of force. These seats of force are distributed in articulata and vertebrata in two general systems, which are more or less connected with each other.

The articulated animal has two *ganglionic* systems; that which promotes all its mental actions, and that which occasions all its vital functions: the one system is found in the double *subventral* larger ganglia, the first of which is in the head. The other is variously distributed throughout the region containing its *viscera.* Both these systems are intimately connected with each other, and they both belong to the instinctive or *automatic* phenomena of animated Nature.

The vertebrated animal also has two ganglionic systems, but that which corresponds with the line of distinct *subventral* larger ganglia of articulated animals, differs from it in many important particulars. It is a consolidation of those ganglia, and as such is called the spinal chord. Down its whole length, it is accompanied by two sets of nerves proceeding from it: in one of these sets, each nerve has a special ganglion, and observations have proved that the nerve in question is an organ of *sensation;* while those of the other set having no ganglia, are organs of *motion.*

These *accessory* ganglia differ altogether from those belonging to the sympathetic system, which are distributed throughout the viscera, and which correspond with the minor or vegetative ganglia of the articulata. Still there is a most intimate connection between the spinal system with its accessory ganglia, and the general sympathetic, or ganglionic system, in the vertebrata; precisely as there is between the system of the larger subventral ganglia in the articulata, and the more delicate ganglionic system of their viscera.

In addition to the spinal chord, vertebrated animals have a distinct *cerebral* system, situated at the upper end of the spinal marrow, in which all the apparatus of special instincts or sentiments, and of reason, are brought together. This cerebral apparatus is more or less developed according to the organisation of the animal, which may be the object of observation; and although a distinct system, it is connected directly, or indirectly, with the spinal marrow and its accessory ganglia of sensation (as well as its nerves of motion), and with the quasi-vegetative or visceral sympathetic system of ganglia.

By as much as the portions of the brain peculiarly attributed to the production of judgment and reason, are predominant, by so much is the vertebrated animal a *comparatively* free agent: but even when he is so gifted, his two orders of ganglia,—those of the spinal chord, and those of the visceral system,—influence his mind. The first occasion the general sense of touch, and probably of every other sense, when they are affected by any change in the nature of external or internal matter, with which the nerves ramifying from them, may be in contact; and they communicate to his sensorium the idea of physical pain. The *visceral* ganglia appear to be even more mysteriously connected with the brain; for when they are excited, they derange its functions, and make it create the most erroneous ideas on matters of fact, or call up a host of disagreeable sensations, which, although not those of bodily pain, are feelings much more distressing.

Our first inference from this physiological method is, that madness may be ascribed to an extraordinary excitement of the *visceral ganglia*, when it is not to be traced to some direct injury of the brain itself. The next and important deduction as bearing upon the phenomena of animal magnetism, is, that the *accessory ganglia* of the spinal chord are peculiarly affected during the state of magnetically-induced somnambulism. And the general conclusion is, that as the exciting cause of madness, and dreams, and of naturally-occasioned somnambulism, may sometimes be an abnormal state of the *visceral* ganglia, acting sympathetically upon the brain, and creating within the body an irregular series of phenomena which cannot be traced to any external cause,—we are justified in supposing that the magnetiser has a power of stimulating both sorts of ganglia, and of thus influencing the brain through the nerves which connect them with it.

The suspension of the normal senses in such cases, leads us to imagine that the somnambulist's *spinal ganglia have their attributes entirely changed:* that they cease to convey the feeling of touch, and of bodily pain; but that they become the organs of a general sense of perception, conveying *inductive* impressions to the sensorium from objects, which, under ordinary circumstances, would not affect it through the eye, or ear, or any other special instrument of the senses.

If the lowest articulated animals had brains, it might be assumed that the faculty in question, which is here attributed to an excitement communicated through the ganglionic system in the nervous body, was merely a substitute for that of the ordinary senses; but we have seen, that it cannot be proved that the first or upper ganglion of the insect is a cerebrum, or the only organ of the mind, although it is evidently an appendage to the organs of perception, and especially to the *antennæ,* which are most probably the organs of magnetic communication with the external world. Insects in a perfect state are covered with a horny substance, which may necessitate the condensation of this faculty in such a special organ in them, while it is diffused over the whole surface of the human body.

All the communications of bees in their dark hives are carried on by means of the antennæ. If a glass hive be constructed with a sort of vestibule, it will be seen, that as soon as bees arrive there with their loads, they take up their station in it (the ledge before the entrance of a common hive stands in lieu of a vestibule on such occasions), and announce their presence by a continued buzzing of their wings, until they are summoned to the interior: a bee will come out of the inner part of the hive and touch the antennæ of several of the new comers in succession with its own antennæ. Each bee so touched, goes into the body of the hive, but the others do not move; after about six or eight have been called in, the summoning officer of the hive follows them. In this instance, the antennæ correspond with organs of speech, and they are probably informed to what part of the hive they are to go, in consequence of the antennal contact. Other phenomena of the same order, such as their respectfully touching the queen bee with these organs, as she passes by them in their hive, imply that the antennæ must convey a sensation analogous to that of magnetic communication between the animal magnetiser and his patient: it is probable also that the antennæ are the supplementary organs of every sense, precisely as the ganglionic spinal nerves of sensation are supposed to be in the vertebrated somnambulist, according to our hypothesis. Such an explanation of the functions of the antennæ, accounts for the differences amongst naturalists about their properties; some of whom say, they are the organs of hearing. It is also corroborative evidence in favour of our supposition, that there is a resemblance between the *normal* state of the general nervous system in the articulated animals, and the *occasional* condition of the magnetised human being.

We are therefore warranted in the conjecture, that the mind of the insect depends upon its whole sympathetic system, or both sorts of ganglia. When the analogy is applied to the case of the somnambulist, we must not only speculate upon his spino-ganglionic system acting as the organs of the senses do on ordinary occasions,—but that his visceral ganglia excite sentiments, which are not developed by his brain when he is awake; and that they therefore assist and heighten the cerebral faculty. Thus at that moment, he may be said to be in possession of two minds,—the one depending upon the nerves of his visceral ganglia in connexion with the brain,—the other upon his spino-cerebral system alone; both of which are however so complicated with each other, that it is impossible to decide to which of the two he is immediately indebted for certain powers of his magnetically improved intelligence.

There are some phenomena, however, incidental to this condition of a human being, which demonstrate, that the somnambulist is endued with much higher faculties than those of a man awake. Recollection is an accountable mechanical power of recording events or objects communicated to him through his senses: a portion of his brain is an encyclopædia, in the pages of which the occurrences which he remembers, or the forms which he has seen, may have been really noted down; and his reason applies to the memorandum upon emergencies. This power is also connected with instinct. But foreknowledge is *exclusively* an *instinctive* quality, which can be attributed to no such mechanical operation. Most somnambulists, and many persons whose ordinary sleep is accompanied by vivid dreams, have the *talent of foreknowledge*,—a talent, be it observed, which is possessed by the lower animals, as an undoubted instinct. Birds calculate the distance of their migrations according to the forthcoming intensity of the weather, long before the usual change occurs. In these and a multitude of similar instances, the faculty can only be *instinctive.* Reason cannot influence the conduct of the animal upon such points; and no power of reflection can assist the human prophet. Instinct alone becomes the prompter in both cases.

Somnambulists are often extemporaneous doctors. That they should be able to perceive the diseased internal parts of their own bodies or those of others, is compatible with the notion of an inductive power of perception, which in itself, though more unusual, is not more wonderful than our seeing a distant star through glass, or the ponderable atmosphere of the Earth: but that they should be able to recommend remedies, and to foretell periods of crisis in disease without the advantage of medical experience, must depend upon some faculty which resembles that of foreknowledge, while it demonstrates the same sort of instinct as that which prompts the mangouste of India to seek the *ophioriza mongos,* an antidote which enables it to defy one of the most venomous serpents in that country.

Our explanation of these phenomena is complete, if we admit that instinct is a constant attribute of the animal, however he exalted he may be; *that in the lower stages it directs his conduct entirely;* but that when reason accompanies it, the animal having the double apparatus of mind, is more or less guided by his *own will.* It is a corroboration of this hypothesis, that except in some rare instances, the will must be annihilated before the high faculties of the somnambulist are called forth. He must either be thrown artificially into such a condition, that he obeys his magnetiser, as if he were an automaton,—or that his imagination is no longer under the influence of his reason, as is the case in dreams. Sleep-walkers especially are in this predicament: they are impelled to quit their beds and move under a spell created by their own imagination.

Madness itself, under certain circumstances, is connected with this subjection of the will to the imagination; but the causes of the disease are more complicated, because the cerebral *organ of reason* is often badly formed, or impaired. Yet if we reflect upon the connection between disorders of the intestinal canal (occasioning an irritation of parts of the ganglionic system) and those of the brain, we may find that, in endeavouring to subdue the fever of the brain by applications to the head, the origin of the complaint may not be touched, and that the balance intended by Nature, between the cerebral and ganglionic systems, cannot be restored, unless the intestinal canal be attended to. By treating that part of the body as the seat of the disease, and beating down the empire of the ganglia, physicians often rescue the brain from its melancholy slavery, as if by magic.

The great anatomists of modern days, more particularly in England, have shewn that the nerves of feeling and those of motion, which emanate from the whole length of the spinal chord, differ from each other,—those of feeling being always interrupted by a sort of ganglionic protuberance, which is not found in the other; and this holds good as regards the fifth pair, which is so much concerned in pains in the head and face. The larger portion only of this nerve has a ganglion, the other portion is not so swollen out, and is proved to be only an organ of motion. The sentiment of touch which is conveyed to the sensorium by this order of nerves is altogether annihilated in the somnambulist, who may be pricked with pins or needles without feelings of uneasiness.

Hence we infer that during somnambulism produced by magnetic agency, there is a suspension of the ordinary influence of the order of ganglia which are connected with feeling or touch, and that some physiological change takes place in consequence, which converts them, or the nerves which belong to them, into a general organ, capable of conveying impressions of another description, both to and from the sensorium.

Therefore the general ganglionic system *in all animals* may be endued with two different qualities, the one holding a relation to *conductive*, the other to *inductive* electrical action. Sensation produced by *atomic contact*, ought, according to our physical hypothesis, to depend on the *conductive* process; while that which results from a magnetic reciprocity between bodies, is occasioned *inductively* through the medium of the non-atomic ether, which pervades all such bodies. The phenomena of the extraordinary powers of perception in the somnambulist are in accordance with this speculation.

We hear when we are awake, because impressions are made upon the nerves of the ear by the undulations of the atomic air with which they are in contact. When somnambulists seem to hear, the process cannot depend on the *ordinary* senses, if they appreciate the import of words spoken at great distances, where walls or other obstacles impermeable to sound, interfere. The author has witnessed instances of magnetised patients being deprived of all sense of touch in the body, but not in the head and neck; in such cases, the auditory nerves and those of the fifth pair, may not have been affected by the magnetic influence; but as this will not account for the perception of words spoken at great distances,—may we not conjecture, that the same general faculty, which enables them to see when the eye receives no impression, gives them a sentiment analogous to the idea which is conveyed to the sensorium by the organ of hearing when they are awake? It is probable that they have a magnetic power of knowing the ideas of those with whom they speak. *Spoken* words may not be necessary

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in the communication of such ideas to the sensorium of the somnambulist, although they are needed to convey *his* ideas to the magnetiser, and to others with whom he converses during his slumber.

It is also evident, that somnambulists may have all the motive nerves in activity, as well as those of the cerebral system. In some cases they may really see and hear with their eyes and ears. But as the will of the patient becomes subservient to that of the magnetiser, there is an analogy between his condition at that moment, and that of the lunatic when he is under the influence of a derangement in his ganglionic system: his reasonable will, like that of the insect, gives place to an impulse of *necessity*, which has the semblance of will resulting from judgment, and usurps its power over his nerves of motion and all his mental qualities.

When the will, which peculiarly distinguishes the conduct of the animal having the most perfect brain, is brought under the subjection of a magnetiser, or, during automatically-produced dreams, under that of its own imagination (and this happens still more decidedly in cases of aberration of mind), the cerebral activity and its reasoning powers are as blindly *instinctive*, as the complicated intelligence of the bee or ant is.

To term the *cerebrum* of the vertebrata a *ganglion*, or a congeries of ganglia, may not be critically correct; but since it has many of the same functions as those which belong to the ganglia of insects, and like them it falls under the empire of instinctive laws in the somnambulist, we may infer that it is in some respects like a ganglion in the articulated animals. Still, these two sorts of *mental* organs must belong *categorically* to different specific types, as regards the general laws of animal physiology, and we are thereby justified in suggesting,—

1st. That there are two distinct nervous systems in the animal world ; the one connected with *externally derived instinct* and *necessity*,—the other with *internal reason*, and choice resulting from *judgment*.

2ndly. That the material instruments of the one order of faculties are found in the *ganglionic* system, those of the other in the *cerebro-spinal* system.

3rdly. That in the lowest animals, including the *radiata*, the ganglionic system predominates; and that there it is the source of instincts and of the sense of touch, which sense induces irritability.

4thly. That in the articulated animals, the ganglionic system is still predominant; but the distinct senses are developed in consequence of its higher organisation, and of the division of that system into distinct sets of nerves, which separate its instinctive organs of mind from those of its senses, and from those of its motive powers.

5thly. That the molluscs exemplify a condition of transition between the vertebrated and articulated animals, and between the ganglionic and cerebro-spinal nervous systems.

6thly. That in the vertebrated animals there are both systems,—that of the visceral ganglionic nerves, and that of the cerebro-spinal apparatus, which last predominates under ordinary circumstances.

7thly. That the cerebral apparatus is always accompanied by a spinal chord in vertebrated animals, although they are distinct from each other; *that the fifth pair belongs to the spinal chord;* and that to the cerebral portion of the general nervous system in such animals, and more especially in the mammifers and birds, must be attributed all voluntary acts depending upon judgment and reason, which are always proportioned to the capacity of the frontal parts of the brain.

8thly. That the *irrational* instinctive system, even in man, may, under certain circumstances, be made to predominate,—the change occasioning the temporary paralysis of the *conductive* qualities of the ganglionic nerves which are attached to the spinal apparatus, but substituting for them a general *inductive* faculty of perception, which is far more powerful. That this does not suspend the *motive* powers of the spinal system, nor the reasoning faculties of the brain,—but on the contrary, that it exalts the reason, although it controls the will in the same way as it is controlled in the bee or ant. The complicated result is therefore a mental capacity far exceeding that of such articulated animals, because all the reasoning faculties of the brain become amenable to a master power analogous to that of collective instinct, and the whole category of humanly conceived ideas is then placed under its control.

Such an analysis will assist us in an attempt to investigate the complicated connection between phrenology and animal magnetism. Gall, the founder of phrenology in its modern form, busied himself with the investigation of the brain, and attributed all mental acts to the cerebral apparatus. So far as his system goes, it is a noble monument of inductive philosophy; and he was the first physiologist who taught anatomists to dissect the brain in a satisfactory manner: but it is not to be expected that he should have been correct in all his conjectures. The strictest analogy is hostile to his opinion, that the grey substance produces the white substance of the nerves; and he has committed some other obvious mistakes, which are eagerly laid hold of by persons prejudiced against his doctrine, or by those who have been eager to appropriate to themselves the merit of having made discoveries which were undoubtedly his.

One remarkable error in Gall, however, was his having directed attention solely to the cerebral organs, and having endeavoured to depreciate the doctrines of others, who had referred some mental qualities to the ganglionic or sympathetic system. It was the natural consequence of this mistake that he should have neglected the instincts of the lowest invertebrated animals, where there is no cerebral apparatus. His great work is not what it professes to be, the physiology of the nervous system; it is really a treatise on craniology, if that term may be applied to the acts of organs contained within the scull.

But as regards his main propositions,—that the brain is the organ of the mind in vertebrated animals,—that different parts of the brain are the subordinate organs of different mental properties,—that the cerebrum differs from the cerebellum, while both differ from the spinal chord and its appendages,—that certain lower instincts are occasioned by the activity of those hinder parts of the brain, which are behind a line drawn from the apex of the scull, to the opening of the ear,—that in the lower part of the forehead are found the organs which make persons linguists, artists, geographers, travellers for pleasure, arithmeticians, or men of business,—that in the higher parts of the forehead we discover others, which give their peculiar powers to the mathematician, the poet, the wit, and the logician or metaphysician,—that benevolence, religion, hope, and marvellousness, depend on the upper parts of the cerebrum between the forehead and the apex, while firmness flanked by caution belongs to the highest portions of the *central* regions of the brain, and combativeness and destructiveness are in the lower parts of the same central region;—as regards these propositions, there is a harmony in his views, and a fitness in his scheme of apportionment, which render it worthy of deep consideration.

One of the mental qualities, however, which he least notices is that of *marvellousness*, and his followers in general treat it most illogically. While they attribute to every other imagined organ of the brain a well defined and specific function, which is a necessary part of the great scheme of the mind in man, they are almost all inclined to regard the quality which they assign to their so-termed organ of marvellousness, as if it were only calculated to create delusions, and to interfere with sound reason.

Its locality is worthy of remark. Considered generally, it occupies part of the region behind, but rather above the temple, giving that part of the head the appearance of an edge or angle; and so raising the temporal muscle, as to make its motions very perceptible upon the temple, when the lower jaw is in action. It is in the neighbourhood of the organs of veneration, benevolence, and ideality or lofty imagination, all which mental properties are of the highest class of tendencies or impulses, and partake of the character of instincts. It is particularly remarked in persons who are fond of the mysterious and occult sciences, in those who dream much and prophetically, or are said to be endowed with the powers of second sight, in natural somnambulists, and those who are subject to spectral illusions, in those who are amenable to the influence of the magnetiser, and in those who have great powers of magnetising others.

This distinct cerebral region may be regarded as the general organ of that part of the mental apparatus which is connected with the highest instinctive faculties, and is often found in imaginative persons who are not remarkable for judgment. In the earlier stages of civilization, it may have been more fully developed in the human race, than it is at present. The fact that literature has generally commenced with poetry, and that prose history is the production of a more advanced stage of the education of a tribe or nation, demonstrates, that in the savage state of man there is a greater tendency to the mystical and romantic, than when his reasoning powers are more developed.

Now, it is possible, that when the organ of marvellousness is strongly developed and not controlled by judgment, it may induce the most extravagant conduct, and the most absurd superstitions. Persons whose minds are thus affected, may be dangerous members of society: when they never reason upon cause and effect, they may be carried away under its influence, and be thereby more easily brought into subjection to the lower instincts; they may find a romantic pleasure in being robbers or murderers. If they discover that it endows them with extraordinary powers of magnetism, they may employ those powers to the injury of others, and to the promotion of their own intensely selfish purposes. But if they are benevolently disposed, and have sentiments of veneration for what is exalted, this superior faculty may occasion conduct worthy of an angelic nature.

The mere instinct of veneration unaccompanied by reason, is not religion. But human reason without some self-devoting stimulus of an instinctive character, would be a cold calculating power tending to no object beyond the promotion of self-interest and the advancement of an irreligious material philosophy. Few men, however, have such a mental constitution, that they are not mainly guided by selfish instincts, and that they do not use their reasoning power as an instrument in reference to these impulses; for self-esteem and vanity, and a desire to possess property, or to command others, are the *ordinary* mainsprings of calculating reason in social life. It is difficult to conceive a greater misfortune, than that the reasoning faculties of the human race should be wholly devoted to the promotion of the mechanical doctrines, which mask the self-seeking motives of the utilitarian school. A nation guided by such principles is really relapsing into barbarism: they have all the most ignoble feelings of the savage without any of his virtues, and they would replace his romance by meanness and dishonour.

It is not, however, in the destiny of our race, that this should happen throughout the world; for although the habits of social life generally tend to diminish the natural energy of the organ, or class of organs, which are called those of marvellousness by phrenologists,—and this may occur, while the reasoning faculties of successive generations are progressively improving,—there are certain series or races of men, in whom the organ in question remains in full activity. In the general phrenological scheme, the *romance* induced by the organs of marvellousness and imagination, is a useful check upon the *selfish* interferences of clever but short-sighted individuals with the well-being of societies to which they belong: and if the double influence of these organs upon human conduct be controlled by experienced judgment, it may be productive of results far more valuable than the responses of the sybils or the visions of seers in less civilised ages.

Whether we succeed or fail in the endeavour to discover the locality of the important cerebral instrument to which these higher properties may be attributed, we find reasons for supposing that it must have both active and passive qualities.

1. It gives its possessor the power of reciprocating with other bodies by a general sense, which answers the purpose of hearing and seeing; and it enables him to observe every portion, internal and external, of his own and of other bodies.

2. It assists, and sometimes it governs his own reasoning faculties; and in this respect it becomes an *all-controlling organ of instinctive intelligence.*

3. It supplies him with instinctive general *knowledge*,

which, if attainable at all by the ordinary methods of gradual instruction, he may have had no opportunity of acquiring.

4. It enables him to foresee *future* events,—a talent explicable upon no hypothesis in which sensation, recollection, and reason, are the only elements of a mechanical method of obtaining such powers of foresight.

Then as regards the magnetiser's influence over other bodies, between which and his own there is a relative reciprocity of *power* and *subjection*,—the same organisation may be supposed to occasion—

1. The spell-like energy of the magnetiser, which produces somnambulism, and places under his control the somnambulist, in whom it paralyses the ordinary nervous faculties, but elicits new and unusual powers as regards perception and intelligence. The most extraordinary circumstance connected with the phenomenon is, that in its highest manifestation, this complicated effect is produced by an apparently simple force,—the mere *will* of the magnetiser to throw the patient into the state of somnambulism,—while the magnetiser himself does not thereby gain any of the faculties of the somnambulist, who is at that moment the most exalted creature of the two.

2. There is, however, another species of this magnetising power, which is of a higher character. It occurs without the necessity for throwing the patient into a state of somnambulism, and it does not appear to exalt his perceptive or reasoning faculties; it seems to realize the mystical idea of possession; it therefore renders the magnetiser a superior being to the patient in all respects. This faculty is observable when such a sympathy is established between two animals, that the one obeys all the mentally conceived orders of the other, without any *apparent* change of its mental state, and without *seeming* to be

deprived of its own will. Man has this power over animals to a great extent.

Exhibitions of learned horses, and of trained wild beasts, derive their interest from its development. It is curious to remark the different effects produced upon different species of the same genus. The panther and leopard become affectionate like cats; the lion seems stupified; the tiger is merely brought into a state of unquiet subjection to his magnetiser. The insect tribe are peculiarly subject to the influence: the prevalence of the ganglionic system of nerves in all articulated animals will account for their being more amenable to it, than the vertebrata. Molluscs are easily influenced when they are touched with a magnetic intention: although under ordinary circumstances, when they feel the approach of any external body, they persist in adopting their natural means of defence, which are those of closing their shells, or retiring into them, or exuding a slime over their bodies, or pretending to be dead,—they resort to none of these devices of self-protection, when they are influenced by the magnetiser.

3. Contact is not necessary to the reciprocity, nor is any distance between the magnetiser and his patient an obstacle to the transmission of the influence. It is probable that it occurs as any other process of electrical induction between bodies would do under similar circumstances,—that as regards time, it has the rapidity of light, be the distance between the bodies what it may,—and as regards space, its intensity may depend upon the extent of the intervening distance, as that of gravitation does, in accordance with the known laws of physical forces. Still it is evident, that the process is one of a dual reciprocity, in which there must be a definite limitation of distance.

So far as its phenomena can be *known*, the limitation must occur within the general boundary of the earth's atmosphere. The argument, however, would suggest the possibility of the existence of such powerful animated forms of matter upon the surfaces of celestial bodies, that they might be able to influence animals inhabiting other heavenly bodies.

The substitution of a general sense of perception in the somnambulist, which enables him to have a more accurate notion of objects, than that which depends upon hearing or seeing,—and the extension of the nerves of this supplementary sense into every part of his body, where those of touch produced by the ordinary nerves of sensation are paralysed during the magnetic state,—has already suggested that the spino-ganglionic system of the whole body is converted into a general organ of perception in such instances. But we may also infer that a magnetiser can *directly* stimulate the organ of marvellousness in his patient,—which would equally explain why the somnambulist is in such a state of subjection to his magnetiser, or why in natural sleep he is so under the control of his own inherent imagination, that reason ceases to prevail in his dreams.

Occasionally, somnambulism is a very exalted state of animal existence, more especially when it causes the self-development of religious ideas. The possibility of our being prone to act wrong, is itself an evil in an ethical sense; and our reason would induce us to make a willing surrender of the liberty of choice, when it is clogged by the tyranny of those predominant instincts which outweigh the noble impulses. To be compelled, as the bee is, to act right, and to have a pleasure in obeying such an impulse which that wonderful animal undoubtedly has, would be a more satisfactory condition, than to have a choice between good and evil, if we were exposed to irresistible temptation. Upon these grounds we may suppose, that the bee holds a higher position in the parallelism between articulated and vertebrated animals, than that of the human race. But if our lower instincts could be annihilated, we should have all the advantages enjoyed by the bee, added to that of possessing the powers of generating new ideas, which the bee has not. Under such circumstances, choice in regard to conduct would be an unalloyed privilege.[z]

[z] The working bee (the most intellectually perfect of articulated animals), is not under personal subjection to the instincts necessary to the propagation of the species,—a provision of nature admirably calculated to prevent lust from interfering with devotion to the interests of the commonwealth to which this insect belongs. Such considerations may lead to the surmise, that the bee occupies a higher relative position in the general scale of mental organisation, where there is no choice,—than that of man himself in the parallel order of progression, where conduct depends upon the determination of free judgment. The bee's veneration has for its object the queen of the hive; its benevolence is directed to the welfare of each member of the community: its local attachment makes it consider the hive its country: its hope induces it to look forward to the prospective advantages which the hive will derive from its own exertion: its desire to please has reference to the queen, and to its fellow-subjects: and its conscience, or sense of what is right, controls its self-esteem, which is always a necessary stimulus, even when self-immolation for the public good is the result, but without which, there would not be a due care for its own life.

The veneration for the queen in the beehive is the counterpart of that for God in the human mind; but our selfish passions too often occasion a neglect of duty both to God and man, and overcome our noble instincts of veneration and benevolence. An analogous misfortune never happens to the working bee. We have the liberty of judgment and of choice between obedience to the brutal or to the social impulses, which the bee has not. Still there is an evident imperfection in our nature, and the power of forming right judgments and of adhering to them must depend to a great extent upon the comparative instinctive force of the noble and ignoble impulses, as well as upon that of the organs of reason, which are differently constituted and balanced even in twins, who during their embryo state, have been joint tenants of the same living cradle.

SECTION XX.

General considerations on the preceding sections.

We have thus attained a position in the consideration of *physical* phenomena, which borders on *metaphysical* regions; we are on the confines of that branch of science in which psychology becomes the basis of every problem, and where, —although physics are inseparably connected with all manifestations of those higher developments of Nature's laws in which *human* intellect is concerned,—the existence of a *sentient Being* is a new axiomatic starting point indispensable to the explanation of any phrenological incorporation. The difference between inorganic and organic phenomena is indeed self-evident, and the first introduction of *vitality* as opposed to the *mineral* activity of matter, is perfectly clear and well defined: but the limit between that higher display of physical force, on one side, which maintains life in the organisms both of plants and animals, and the *sensitive principle* of animation on the other—is far more decided.

To apply the word "principle" to the vital force, is to insist upon an absolute distinction between the sources of a progressively improving electrical activity, which is made manifest in different degrees of complication both in the inorganic and organic world: the term "principle," in its most critical sense, is really inapplicable here. But in dealing with the phenomena of *animation*, we are investigating the connexion between physics and psychology,—or between that first comprehensible energy which pervades the whole compendium of *material* organisation, and the fundamental *element* of animal *consciousness* without which it is impossible to account for our own perception and volition.

There is no greater difficulty in admitting the existence of the *psychological element* than that of the *primal physical force* which is a necessary postulate in our material scheme. No experiment or observation will account for the *origin* of either principle. Supposing our doctrine to be correct as regards the aboriginal generation of the atom, no available hypothesis can be suggested which will offer a satisfactory cause for the existence of the dual pointlike incorporeal entities of force, whose reciprocity (according to our scheme) occasions that *first* development of physical activity in a limited portion of ethereal substance which originally caused its segregation from the all-pervading mass; neither can any supposition about the origin of each *sentient* Essence as an individual Being, be advanced in our present state of knowledge, which will withstand the reasonable criticism of the *metaphysical materialist.* It is one of the conditions of the great problem, that as regards *embodied* mind, every psychological theory should harmonize with physical observation.

Still there *is* a region of transition between physics and *pure* metaphysics, which is open to our observation: not only shall we find that the mind and the sentient principle of every animated body, and consequently its every idea, are in subordination to physical laws,—but that one great and connected scheme of NUMBERS prevails throughout the whole system of the comprehensible world, in reference to *the social occurrences* of all its animated organic creatures, as well as to the mode in which every organic and inorganic atomic body on this planet, has been compounded by an unerring Providence. We may be assured that *all* the phrenological events of the mighty scheme, (even with respect to our own *apparently free volition*), hold as harmonious a relation to each other, and must be as much *predestined,*—as the so-called accidents or chances of inorganic phenomena. But it is not in an essay upon physics that this incontestable truth should be examined; it belongs to the highest branch of metaphysical study.

In the preceding sections of the present essay, it has been attempted to demonstrate, that the entire scheme of Nature is one of a continuously improving development,—that this applies to all the varieties of electrical forces (each of which may be treated as a modification of the first conceivable basis of physical activity), as well as to the most complicated *formal* phenomena of the material world, which may be traced back to the simplest corporeal realisation of our ideas of form;—and that there is a connexion between such a physical development of forces and forms in Nature,—and the self-developing geometrical system of abstract forms, which the human mind is capable of reducing to first principles by mathematical meditation.

The method adopted with the object of demonstrating this doctrine, which bears so directly upon the question of the transmutation of species, and indeed upon every chemical, astronomical, and geological theory, may be condemned as tedious: on the other hand, the inferences at which the author has arrived, may appear hasty in many particulars; and men of science may complain that more details were necessary in order to substantiate his subordinate hypotheses.

It must be remembered, however, that in the present treatise, he has only proposed to go through the *outlines* of a physical theory. In the next essay, he enters upon the endeavour to construct a geometrical series of numbers, which is in itself a system of perfect and surprising harmony; and he suggests that this series, or one in many respects resembling it, is the basis of those laws of numerical proportion, which prevail throughout Nature.

ESSAY III.

OUTLINES OF A GEOMETRICALLY-ORIGINATED SERIES OF NUMBERS.

CHAPTER I.

ON THE MATHEMATICAL METHOD OF ATTAINING OUR FIRST IDEAS OF NUMBER.

SECTION I.

On the ideas of fractional *numbers deducible from the self-suggested division of the circle.*

WE have already shown that a circle is the simplest superficial figure which can enclose a portion of space. (See Preliminary Essay.) A triangular or polygonal superficies must be constructed with the assistance of one or many circles and tangent lines; or if such instruments of proportion as compasses be used, by a still more artificial method. Yet notwithstanding the simple origin of the ideal circle, no other superficial figure is so complete a representation of harmony, of centralization, of limitation as to extent, and of eternity as regards the continued character of its circumference. It has been long used as a symbol of abstract time; and when figured by a serpent or the emblem of wisdom, it has been a mythological type of the Supreme Deity in more than one ancient religion.

We have also seen, that, if we imagine the ideal straight line (already applied to the formation of the circle) to be *at rest* within it, instead of *in motion*,—the figure will be one of two semicircles, united so as to form a perfect circle, yet capable of separation into two equal parts without any artificial process of measurement.

We cannot call the expression of unity a number: it is as much the universal sign of a totality, as it is of one single thing, when considered in its solitary capacity. When the word *one* is treated as a *relation* to something else as a distinctive sign, it is a number, and it becomes an evident arithmetical term, if applied to its own counterpart;—*a solitary* point in space is a totally different entity of the imagination from a point which holds a relation to *another* point.

This difference becomes apparent in its simplest *formal* character, when we compare the idea of a circle with that of two distinct but connected semicircles, which may constitute it. In this case, *two* is the expression which denotes the integral unity and totality. It is the *same formal* thing as the original *one*, so far as quantity is concerned, although *one itself* then becomes a term of arithmetical proportion. Hence, in the first idea of formal division suggested by a straight line *at rest* after it had been moving or revolving on its central point, *two* does not represent integers or separate and independent units, but the equal fractions of an entire divisible whole. Yet *two* in this instance so far differs from *one*, when both are used as signs of a totality, that it must be a compound idea made up or growing out of two separate ideas; while *one* may be absolutely independent of any other unit, supposing it to represent a solitary point or the infinite space in which that point is in ideal existence.

Proceeding in our progressive method of generating new ideas of form by imagining alternations of motion and rest, we shall find that the renewal of the motion of the rotating diameter of the circle, and its second cessation of motion, would offer the formal idea of a circle divided into *four* areas: and the repeated alternations of motion and rest, if the times of the motion or the periods of its duration were varied, would divide the quadrants into as many angular figures of different proportions as there were repetitions of the alternation. All this would take place without any new ideal relation or element of form, provided the original distance between the two points were maintained.

Still there are only *two* general sorts of form in all the subdivisions of the circle,—that of the semicircle—and that of an irregular triangle, in which the two radii of the circle constitute two of the sides, while the third is a portion of the circumference; and as the two radii are together equal to the diameter, the difference in the *quantity* of the ideal *lines* employed is reduced to the difference of the arcs of the circumference included in the figure.

Hence the bisection of the whole circle is the first ideal operation of abstract *division*, which is formalised in the mind. *Two*, as a demonstrator of parts, is also developed in a double capacity, as a sign of distinct parts and of totality. When the renewal and the second cessation of motion suggest a new order of form, and of abstract division, *four* appears as a demonstrator of the number of parts into which the circle is divided, and it takes the place of *two* in being the sign of the integer or of totality. *Four* therefore is suggested mathematically before the intermediate *three;* and two and four stand alone during the continued operation of the self-division of the circle, as the types of the distinct orders of form thereby generated, no matter how many subdivisions of the quadrant may be the result of renewed intervals of the motion and rest of the diameter.

No subsequent operation of the same description will divide the radius or half the original straight line: and here stops the process, which suggests ideas of quantities of parts by *division* in connexion with the division of the original straight line.

The semicircle and quadrant are therefore not only the first forms under which the automatic mathematical separation of the formal emblem of unity develops itself, but they are each at the head of a class of formal ideas, one class depending upon the diameter, the other upon the radius of the circle; and all subdivisions of the quadrant are equally subordinate (as regards the length of two of their sides) to the radius, or the half of that diametrical line, which was the parent idea of that of the circle itself. Finally, the process of doubling a given number, or of dividing it (exemplified by two when *multiplied* into itself, or by four when *divided* by two), is the only development of arithmetical truths, which is as yet made manifest to the human mind, in its simplest conception of superficial form, while *two* and *four* represent the most obvious division of such a form.

By the division of the circle, we can only produce irregular figures typical of fractions of unity, which seem incapable of combination in any harmoniously regular form, unless we arrange them *all* in their original centralised position. The hypothesis that the ideas of proportion as regards combination, must be derived from some other mathematical source than that of the *division* of the circle, seems inevitable, if the *natural* selection of certain influential numbers was in any way connected with mathematical speculation.

When the above notions are applied to cosmological theories, we may thereby figure to ourselves some *general* ideas in connexion with the mathematical and arithmetical processes of division, such as the postulate,—that there is a binary and four-fold division of the whole comprehensible world into classes of things or sorts of elements; but the combination of several independent individual essences out of one vast multitude, in definite proportions, has no analogy in the division or subdivisions of the circle, which would rather suggest ideas of a division of unity than of a combination of units.

As yet, *two* and *four* are the only numerical ideas which are generated in the mind by meditating upon the formation and division of the circle. We must search for the self-development of other numbers, and for the relative precedency of such numbers, in a more complicated process of mathematical investigation.

SECTION II.

On the ideas of fractional *numbers deducible from the self-suggested division of a sphere.*

If we want to *divide* the sphere, we may transfer the motion from the circumference to the diameter, again exchanging rest for motion, and motion for rest: when the diameter is supposed to rotate on its centre in only one direction, it cuts the whole space occupied by the sphere into *two* equal parts:

but such an operation offers a decided antagonism to that which bisected the superficial circle, and was not manifested until the original rotation had ceased: it was the first formal result of *rest*. This operation, on the contrary, is one of *motion*; for until the diameter of the sphere is put in motion, it is simply an axis, and the sphere itself is undivided. Supposing we allow the rotatory motion of the diameter to be in any vertical direction, provided it always passes through the original axis of the sphere, we may obtain as many meridian lines as there are changes in the point, where the rotating diameter cuts the equator of the sphere. Still the circles described will be all great circles, and none of them will cut each other, while no one revolution of the rotating line will describe more than one circle, or divide the sphere into a greater number of parts than *two* hemispheres. The result in any case will leave the diametrical line undivided.

A much more *inventive* interference of the *imagination* is necessary, if we suppose the rotation of the diameter to be out of the direction of the axis, than has been hitherto admitted in our attempt to follow the *self-suggesting* process of formal construction. We may suppose the diameter to be suddenly changed, and placed at right angles to the axis on which the sphere was originally generated; and then we may conceive it to rotate in the horizontal direction, and bisect the sphere equatorially, *after* the longitudinal division has been effected: this would produce quarter-spheres instead of hemispheres; but in doing this we quit the simple mode of construction which quadrated the circle.

A still more complicated antagonism is developed in supposing a *second* rotation of the diameter to bisect the sphere, as the first does, *longitudinally*, and the *third* to be an equatorial bisection at 90 degrees from the first and second bisections. This would divide the sphere into *eight* equal parts; and it would be the formal counterpart of the circle divided into four parts. Such an operation, however, needs a change of position in the diameter, which is not a simple transfer of motion, immediately productive of a new form; for the act of bringing down the diametrical line from its axis-direction to the equator of its sphere, is of itself productive of no new formal idea, the only effect being the incomplete scission of a *portion* of the sphere by the fourth part of a revolution of the diameter in the direction of its axis; which change is necessary, as a preparation for the rotation in the horizontal direction. All this is progressive mathematical construction; but it does not appear to belong to this early stage of the generation of new ideas of form, in which every such change gives birth to a new and complete mathematical figure: if such were the case in this instance, we might thus account for the suggestion of *two*, *four*, and *eight*, as signs of the number of parts into which unity or totality is divided.

But although the idea of the formation of the sphere itself, is almost contemporaneous with that of the circle, and it may be considered its immediate successor, we do not advance so far in its division as we do in that of the circle, without resorting to our own invention for a mode of proceeding which is of a complicated character. We only find it dividing itself into hemispheres by a revolution of its diameter, and if we allow the lines which its ends would describe to be as numerous as the seconds in a circle, each of these lines must pass through both poles of the sphere.

The early development of the idea of an axis in the generation of the sphere is of importance, because it deprives the sphere of that perfect homogeneous character even in abstraction, which is the property of the circle: and it suggests the speculation, that the existence of *poles* is an *indispensable condition of ultimate atomic being*.

Since therefore the sphere is to a certain extent irregular, and the circle is the formal type of perfect equality, we are justified in supposing that the basis of formal ideas is to be found in the circle. All conditions of material existence, however, are connected with some ideas of form, which cannot be represented by anything superficial; and as the sphere is a form which most resembles the circle, we may entertain the notion, that all laws affecting matter specially, are in some manner connected with the sphere, although we must search for the normal arithmetical laws of the whole comprehensible world in a more perfect type of order and harmony; namely, the superficial circle.

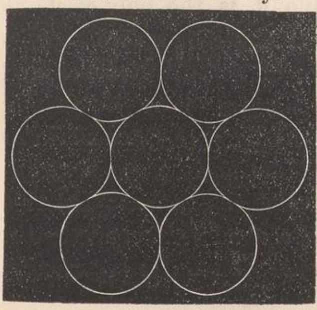
Bearing this assumed maxim in mind, let us endeavour to discover the mathematical rank and succession of numerical ideas in the most obvious combinations of circles, and afterwards apply the table thus suggested to combinations of spheres. We shall find that the great principle of antagonism is prevalent throughout a most perfect system of abstract harmony, which may be evolved out of the harmonious employment of the circular and spherical combination.

Our speculations upon the sphere have suggested no new numbers; and indeed, as yet, we have no ideas of numbers in any other meaning than as so many divisions of unity, or fractional parts of the same perfect individual. *Two* and *four* are numerical terms expressing the ideas thus obtained.

SECTION III.

On the ideas of integral *numbers suggested by the most simple and harmonious combination of similar circles.*

Supposing the circle to be the formal type of the simplest idea of uniformity which human reason can comprehend; such a combination of similar circles as would offer a collective figure the most like the original circular model, seems to be the nearest resemblance to the primary form which represents abstract harmony.



The only low number of similar circles which can be made to resemble the circular form, is *seven;* when they are brought into contact, *one* will be found to occupy the centre of the figure, while the other *six* will constitute a ring of circles, each of which is in contact with that at the centre.

In a figure consisting of any number of contiguous circles *less than seven*, there is not space enough for a central circle; but if the figure be formed of *more than seven* circles, the central circle would not be in contact with the others, supposing they formed a single ring.

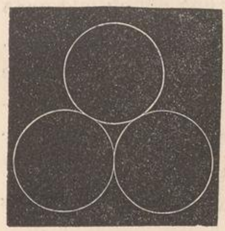
Thus it is evident, that six equal circles forming a ring round *one* of the same size, is the only self-adjusting combination of that description, which possesses the attributes of *fulness* at the centre, of *contact* between the central circle and every other in the combination, and of a *similarity to the original circular form*, so far as that is compatible with its qualities of fulness and contact: although no such circumference as that of this figure can have the form of a circular line, this adjustment gives a nearer similitude to such a form than that which would be offered by a series of tangents fencing in a superficial figure composed of three, four, or five contiguous circles, and describing a triangle, a square, or a pentagon.

Seven therefore is the number which first occupies our attention (in meditating on *formal* ideas and in deducing *numerical* ideas from them) as a sign or term of quantity in the *combination* of individual things. It may be either considered as a collective number expressing the sum total of *six* and *one*, or as an original notation of the quantity of circles employed, without reference to the manner in which they are placed in contact with each other.

The centre or basis of the figure seems from its position to be of more importance than its circumference; and the circle so placed is equally necessary to all the others, as a cementing element of union, while it is the only circle in contact with *all* the others. That circle therefore may be considered as the formal emblem of general qualities and transcendental power, and of that unity which is partially aimed at in the construction of the figure. Each circle in the aggregate has the same individual and independent existence, and the same numerical value, as an unit: but this difference of position between the central circle and the six others, is the first formal appearance of *relative superiority*, where the objects in question are identically alike; the two points, the two semicircles or hemispheres, the four quadrants of the circle, or even the eight divisions of the sphere, offer no idea of comparative inferiority or superiority: with the exception of the *dual* basis (the original two points or ends of the straight line), these ideas only refer to *even* fractions of unity.

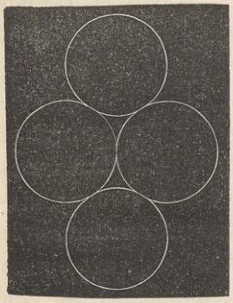
But the number *one*, as an indicator of a single thing selected from or conspicuous among a quantity of similar individuals, is suggested by this figure, as an obvious arithmetical adjunct to our ideas of form. Here it is, strictly speaking, an integer: hitherto it has been a mere verbal designation of a totality, or of some half or quarter of the whole: for the idea of separate and special individual forms was not *then* present to the mind. *Now*, it is not only suggested by combination, but we can suppose the central circle to be isolated, although *co-existing* with the other six circles or with any multitude of similar individual things: we can also conceive it first and singly in our minds, and then create the other six formal images by the power of our reason, and encircle it with them: and thus we assign to it new relative qualities of precedence as to time, and of superiority as to space, although intrinsically it is of no more value than the other similar circles. According to this method of argument, *one* takes precedence of the other number *six*, and they are the two members of the sum total: but our first idea of *seven* accompanies the simultaneous conception of an *undivided septuple form*, and precedes those of 1 and 6, which denote fractional portions of that figure.

Three is also suggested by the formal combination before us: whichever way we look at the general figure, we find it composed of *triple* arrangements of circles, and there are six different and subordinate combinations of *three* circles in this general agglomeration of seven. *Three* therefore, as a numerical idea, grows out of the *formal* representation of seven units: the idea is *subordinate to those of one* and *six*, for they are connected with the principle on which the figure was composed,

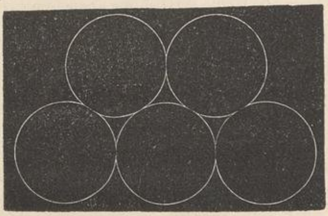


while the idea of *three* is incidental to the whole arrangement as a corollary: but it should be accounted for here, in accordance with the theory which derives this notion from those of formal objects of the human intelligence.

Four also appears, but without the concomitant ideas of harmony that are suggested by the triple arrangement in this combination of seven. In consequence of the position of the six circumferential circles, there may be six different subordinate combinations of *four;* but there is not the same equality of diameter in the figure composed of *four* circles, when the centre of the figure is on the point of contact between two of them, as that which exists in the arrangement of *three*, when the centre of the figure is in the void space common to them all. Thus there are a short and a long diameter in the quadruple combinations, which are subordinate to that of seven contiguous circles. Still the number *four* is the numerical *representation* of the *formal idea* in this instance, as three is in the other.



Five is an arithmetical idea which accompanies a yet more irregular form; for if we suppose any two contiguous circles of the ring to be taken away from the septuple figure, the idea of five is suggested by the remainder. The form which offered *four* as a term of quantity, consisted of the central circle and any three contiguous circles which constituted half the ring: that which suggests *five* is a decided contrast to such a principle of construction, as it supposes the superficial *diameter* of the whole figure (consisting of the central and any two opposite circumferential circles) to be the basis of an irregular figure having four sides and four angles; and the special quality of the central circle, as distinguished from the other six, seems altogether lost or absorbed in the diametrical basis of which it is a portion.



Two, as an arithmetical idea connected with a fixed quantity of individual things, is suggested by the remainder, when the quintuple combination last-mentioned is imagined as a constituent portion of the original figure, which was composed of seven circles.

Now *two* seems to be the simplest numerical idea conceivable by human reason in connexion with objects of our perception; but if we adhere to the process of searching for the origin of ideas of proportion without reference to external objects, we find that *two*, as a distinguishing and defining term of a special quantity of individuals *out of a multitude*, differs altogether from two as a collective number, expressing all the fractions of an integral unity; or even from two when it is suggested by the generating motion imagined in the construction of the ellipse. (See Section v. of the Preliminary Essay.)

But still it may be asserted that our simplest idea of the formal combination of individual objects is of *one added to*, or placed in juxtaposition with, *another*. This simplicity is but apparent, if such a process of formal combination be part of a general process in which *any* quantity (be it typified by a high or low number) is to be adopted in accordance with ideas of form, because it has a *precedence* in time over other numerical ideas, or because the mind conceived it as a relation to form, before the other numbers were thus mentally created.

If one circle were placed in juxtaposition with another exactly resembling it, it would offer no new idea of form in which *compactness* was a relation: it would merely formalise a simple mathematical fact, that there were two forms so nearly identical, that they only differed because they did not occupy the same spacial region: but that in every other quality which indicated difference, they were perfectly similar. Such an idea would be little different from that of two *inert* points in space; and unless the two circles were made to intersect each other, they would produce no new ideas of form, that might not be almost as easily conceived by the employment of the lineal distance between two points. Our two circles in such a case would be but the formal counterparts of the ideal points in space, by which one of them was produced.

It was by the application of *motion* to the two points, that we were able to frame the imaginary circle: motion is an ideal element, necessary to the creation of any formal idea, for the simple symbol of union between *points* (*the straight line*), *produces no new idea until it has been in motion*. The only difference between the two immoveable circles and the straight line is, that the circles represent an enclosed space and have a superficial character, which does not belong to the straight line; but this difference is as much the quality of one circle as it is of two.

What we are looking for, is a succession of arithmetical ideas, arising out of formal images which must not depend upon numerical ideas in the first instance: in accordance with this scheme, we project a form the most resembling the perfect type of form which we believe to be the circle: we do not fix on seven as an *ad libitum* quantity of similar circles with which we propose to constitute the new form, but we decide how many are necessary to image the idea of compactness, and when we have considered the necessity *mathematically*, we perceive that the number can only be *seven*.

There is no formal idea of this nature which would offer *two* instead of seven as a type of perfect combination. *Three* might be so selected, because three circles indicate that number, and a triple combination of equal circles suggests many new ideas of a formal character, such as those of the equilateral triangle; if, therefore, we looked to the *smallness* of the quantity as a reason for precedence, *three* might have formal claims, which *two* has not.

Two, however, appears as the latest secondary idea suggested by a formal combination of seven, and it is the last of the category now under consideration: but this does not militate against the hypothesis, that it is the first term of division as the denomination of fractional duality, which is connected with the origin of ideal form. It is true that the even and the odd, the like and the unlike, and all other ideas of contrariety, are connected with that of *two*, as the term of duality. But when there is no other element of difference, than the occupation of different regions of space, and the two circles are *inert*, such a dual combination does not generate any other idea of form or of number. The line, in its second character, as the bisector of the circle which was generated by its rotation, must be *moved* again, before it is capable of suggesting the idea of a *quadrated* circle: without the adjunct of motion, the line itself would always be *the same*, existing in the ideal figure as a mere figure of division. Hence it follows that the two circles have the attribute of sameness, in every quality, and they do not suggest even a numerical idea which did not exist before; but seven circles, on the contrary, create the distinct ideas of quantity when the figure is considered disjunctively, which are represented in a regular series by the terms, *seven*, *one*, *six*, *three*, *four*, *five*, and *two*.

We have already conceived the ideas of *two* and *four*, as the creations of the mind in *dividing the circle*, and although those terms indicate fractional parts only, in that meaning, while the other numbers were suggested by definite quantities of individual units, they are all numerical ideas connected with each other, and capable of generating new ideas of other proportions by those various arithmetical processes of multiplication, division, addition, and subtraction, which appear to our reason to be founded upon eternal and abstract truth, but which are *connected with power* in a mode altogether above our comprehension.

Hence it follows that the numbers which express a higher quantity of individual objects than *seven*, are originated arithmetically. It is true that, as a fractional term, *eight* has already been offered to the imagination, in the division of a sphere; but we have seen that even then, there was a change of position in the rotating diameter, which is connected with a higher order of mathematical operations than an alternation of motion and rest in regard to the axis diameter of the sphere; because the straight line, in such a case, must be converted into its equatorial diameter. Still in this case, *eight* is only the indicator of fractional parts of an integer; while our combination of seven circles never represents eight as the denominator of separate integers or units. *Eight*, however, is the first arithmetically conceived idea of quantity resulting from the intimate union of the two first numerical ideas which are suggested by the division of the circle. Two connected with four by *multiplication*, typifies *in numbers* the formal operations in the mind which generated new mathematical forms; and the process is itself the model of the various modes in which new forms are generated in the material world.

Besides, *eight* is in every way indicative of the commencement of another order of numerical ideas, and it is the connecting term of quantity between such ideas of number as have a formal origin in the mind, and those which are suggested by an arithmetical process.

SECTION IV.

On the ideas of integral *numbers suggested by the most simple and harmonious combinations of similar spheres.*

If we apply the same mode of reasoning to spherical combination, we shall discover the same formal order of precedence in our ideas of quantity.

It is not possible to arrange so small a number of spheres in a combination having the form of a sphere, as would offer any analogy to the septuple arrangement of circles in a form which resembles that of a circle; nor could they be combined in a form of which equilateral regularity was an attribute, if one of the spheres occupied the centre of the body, as the central circle does in the combination of seven.

Astronomical masses of matter are spherical, or nearly so; but their component particles are incalculably numerous. On the other hand, the general principle of physical *combination* offers no idea of a *spherical* basis, but it seems to have been suggested by an angular radiation from a centre: crystals are angular, although their being cylindrical would offer an analogy to a spherical model; and the experiments made on the effects of sound upon grains of sand, which arrange themselves in new forms under the influence of musical vibrations, indicate that the tendency in such a case is to assume the shape of a radiating star, instead of spherical groups, or superficial circular waves. Such phenomena coincide with the presumption that, although the idea of combination of atoms in particles or corpuscules (which, when themselves combined, give us our notions of simple bodies) may be based upon the *circular model* of form, it has no reference to the *spherical form* itself, as a type of combination. (*a*)

We have already seen that the *triple* arrangement of circles, which appears throughout the combination of *seven* circles, is that which leaves the smallest possible interstice between the circles. *Four* or *five* circles brought together as closely as possible, would leave a larger void; and *six* is the number of external circles in a figure which exactly admits the insertion of a similar circle capable of filling up the void. That mode of combination is undoubtedly the most compact; but the triple arrangement is its basis, and the equilateral triangle which it suggests, is a type of as perfect an angular regularity as the tetrangle or square is, while it suggests the idea of more intense compactness.

When we apply the above considerations to matter, even if we follow the general hypothesis that atoms are spherical, we do not figure the idea of solidity, unless we suppose something more solid than a superficial combination of spheres, because the atom itself in that case would only cohere in one direction. The combination must have depth as well as width and length, in order to constitute a solid body; although we can imagine a single atom to be in itself an independent substantial being, with equal length, width, and depth, the idea of solidity is not satisfied as to *depth in combination*, unless there are at least two atoms to express that attribute in material substance.

We must therefore suppose that the septuple arrangement, which has hitherto been the formal basis of our numerical progression, can only be applied to spherical combination

(*a*) According to the author's hypothesis, the first formal entity, or the atom itself, has an outline modelled upon the idea of the hyperbola.

as a *superficial* model,—but that in order to convert it into a type of *solidity*, we must imagine it to have the depth of two spheres, and therefore to consist of two layers of such spheres, *fourteen* in number.

But if we assume that the triple arrangement (which is an internal and subordinate idea to that of seven circles in contact) be a *model of form* indicative of great harmony, as it undoubtedly is, we extend the complete idea of this harmony to the stage of solidity, by supposing a *fourth* sphere to be placed upon the *three*, with its centre exactly over the centre of the triangular void between them.

When we construct a plane figure by drawing the necessary tangent lines from one sphere to another in this quadruple combination, and by producing them until they meet, we attain the idea of a solid which is a most perfect emblem of harmony and regularity. It will have *four* uniform faces, and *four* equal angles of projection: its constituent basis will exhibit *four* as the number of its spheres. The cubic solid is less harmonious, as that body must consist of *eight* spherical atoms, if constructed on a similar plan, and of *six* equal sides. If angular regularity, compactness, and smallness of the number of constituent parts, be the first and most important principles or primary conditions of that quality of things in combination which we call *solidity*, they are best fulfilled by the arrangement which depends on the mode of contact observable in the septuple combination of circles.

Supposing we add one sphere to the opposite side of the triple basis, we convert that face of the solid equilateral triangle into the foundation of a second figure in all respects similar to that formed by the triangular agglomeration of four spheres, and we produce a sex-facial or double tri-facial solid, with *six* equal faces and *five* projecting angles. Thus by the *addition* of *one* to *four* we attain formal results, which appear at first to double the formal qualities of the original figure. As regards the circles, the idea of *five* was attained by the *substraction* of *two* from *seven*.

Five, therefore, is the number of spheres which follows *four* in this instance, as the next in formal succession; and *two* is the numerator of the quantity of units added to the triple combination, which produces this seeming duplicate of the perfect equilateral solid. No combination of spheres in a square or cubic form will suggest *five* as a numerator or demonstrator of a primary quantity, but by adopting the triangular arrangement to which we have adhered from the first, we attain the ideas of *three*, *four*, *five*, and *two*, *by addition*, precisely in the same order as regards spherical combination, as that which is made manifest *by subtraction*, when we meditate upon the numerical ideas which belong to the original figure of seven circles.

Thus we are induced to adhere to the order of succession already developed by the mathematical hypothesis when applied to the circular form, and we divide the numbers so attained into three categories.

1st. Those suggested by the *division* of the circular emblem of unity, 2. 4.

2ndly. Those suggested by the most compact *combination* of circles, one of which is in contact with all the others, 7. 1. 6.

3rdly. Those suggested by the *disjunction* of the separate individual entities which constitute that form, and by the most compact and harmonious agglomeration of spheres, 3, 4, 5, 2.

The whole series will be 2, 4, 7, 1, 6, 3, 4, 5, 2, or *nine* indicators of quantity: this arrangement offers the first example of a regularity and harmony, which are so wonderful in more extensive combinations, that we almost believe we are dealing with our own inventions instead of mathematical and arithmetical certainties, when we examine them. For instance, 6 is a central number. On one side 2, 4, 7, 1, are equal to 3, 4, 5, 2 on the other; and both groups thus produced equal 14 separately, or 28 conjointly, which is twice 14. But 14 is the double of seven, and 6 is the double of 3; while these identical numbers 7 and 3 are the groundwork of the series of nine cyphers, which, according to one hypothesis, constitutes the entirety of the simple mathematical numbers. Thus our first arithmetical operation, consequent on classifying or grouping these numbers, is to obtain 14 and 6 as new terms of quantity, which are the original numbers *doubled.* The same proportions are found in the three above-mentioned categories, when the place of the 6 is changed. $2+4=6$, $7+1+6=14$, $3+4+5+2=14$.

CHAPTER II.

ON GENERAL NOTIONS ABOUT THE INFLUENCE OF CERTAIN NUMBERS.

SECTION I.

On the traditional superiority of certain numbers.

HITHERTO we have speculated on the mode in which human reason may acquire its first ideas of numbers independently of material forms, and of those objects perceived through the senses, which make us *practically* acquainted with arithmetical laws; and we discover, that the same process of meditation supplies the imagination with *formal* as well as *numerical* ideas.

The hypothesis, that human reason, without education or experience, could attain ideas of form or number in the manner above described, is only advanced as a logical solvent, for the purpose of discovering the capability of reason even in man; but such powers of mind are not developed in the uneducated savage; nor indeed could any man conceive ideas of such a character, if he were placed in a position which deprived him of all knowledge derivable from external objects. But conceding the hypothesis for the sake of argument, it must be admitted, that had we been the framers of the comprehensible world, the above theory would have accounted for our laying down certain *rules* of *proportion*, and selecting certain *model numbers* in the order in which they were first created ideally in our minds.

The general tradition that *seven* is a mystical number, is not less remarkable than its frequent connexion with natural phenomena.

Tradition also attributes a *more sacred* character to *one* of the seven units than to the other *six*. The Mosaic creation is made to occupy a period of six days, the seventh is a day of rest.

The Zend-avesta speaks of seven Amshaspands, or archangels, one of whom is Ormusd, the good principle, the maker of the other six, but he has his rank among them as the seventh or first Amshaspand. It also describes and names seven devils, the chief of whom was Ahriman, or the evil principle, the creator of the others, yet numbered with them as a seventh.

The Egyptians believed that six classes of Genii under Osiris as their chief, were charged with the government of the world, and that these six classes were arranged by him in two separate categories, each of which contained three classes.

In the institutes of Menu, Brigu is represented as declaring that "from the first Menu, Swayambuva (who issued from the self-existing), there descended six other Menus, each of whom produced a race of creatures," and that "these seven Menus, *of whom Swayambuva is the first*, have each during his own period directed this compendium of moveable and immoveable beings."

The Hebrews believed in a fated period of six millenniums of disturbance and of one millennium of rest, as the portion of time allotted to the world's existence; and St. John in the Revelations talks of the "*seven* Spirits of God."

Throughout the works of Plato we find that *seven*, *three*, *four*, and *five*, are treated as mystical numbers. He teaches that the force of the number *seven* was paramount in the first idea of the formation of the world; that *three* was connected with the first combination of distinct things, and that *four* was the sacred elementary number. In his explanation of these dogmas, he appears to be endeavouring to account for traditional doctrines by logical arguments, which are always elegant and ingenious, although sometimes a little paradoxical. Other philosophers, who derived their cardinal opinions from Pythagoras, explained these mysteries by other modes of argument; thus proving that there was a sort of religious agreement about the virtues of certain numbers, although the various sub-divisions of the Greek-Italian school adopted different methods of accounting for the mystical powers of such numbers.

Traditions of this description must have been in existence long before the time of Pythagoras, but his assiduous attention to mathematics, and the deep meditation upon the abstract laws of number and form, which was enjoined to his disciples and their followers, elicited so many mathematical truths, that the harmony developed in the septuple combinations of equal circles may have been one of their earliest discoveries. In their practical physics they were badly informed, but in a mathematical search after truth, and those abstract laws upon which physical order is based, they displayed greater intelligence than, until lately, modern philosophers have been disposed to allow. The atomic theory of the present day required less exercise of thought in the minds that discovered it (with chemical analysis advanced to the precision which had been attained when that important discovery was made), than some of the ancient mathematical ideas with which it accords.

The coincidences between the development of numerical order in the *physical* world, and the relative superiority or inferiority of certain numbers in the *ideal* world, are so constant, that to avoid meditation upon this surprising harmony, would argue a carelessness and an inattention to facts, which are unworthy of an enquiring mind. Several modern naturalists have founded systems upon the notion, that all animals and vegetables are distributed in distinct but connected groups, in obedience to numerical laws: the quinary arrangement of Mr. Macleay, is based upon the supposition, that *five* is a dominant number in nature, and his opinions upon this head have been followed by many accurate zoologists and botanists. But few, if any, attempts have been hitherto made to demonstrate *why* such a preference for any number should be made manifest in the physical world.

SECTION II.

On the most obvious method of considering numbers in relation to phenomena.

It was a capital error of the ancient philosophers to attempt a figure of the universe, and to liken it to a sphere: they proceeded from this idea to suppose that the comprehensible world had a centre (which in most instances was said to be the earth), and to infer that there was but one world, and one soul of the world, who was nevertheless the *subordinate* universal animating spirit.

This arose from their assumption that the ideas of *form* were applicable to their vague idea of the universe, and to space itself; and although they saw the paradox of supposing form to be an attribute of infinity, they got rid of the difficulty by calling space itself a relation. As regarded their ideas of substantial being, they admitted of no incomprehensible world; but, sometimes talking of the centre of the universe, sometimes of its circumference, they willingly forgot that infinite space can have no circumference, and that no one point in space is an absolute centre.

The idea of form cannot belong to the universe *as a whole*, for infinite space is incapable of complete division, while the idea of a complete division into periods is equally inapplicable to that universal time which never had a beginning. But forms and seasons are only to be found in our ideas of a limited region or a limited period, which has no relation of proportion to infinity. Here, therefore, is one of those great mysteries which are beyond human comprehension: we carry our division of a region or a period up to the highest notion of a beginning;—but that notion will be connected with our first idea of *form*, because we can imagine the existence of an infinitely extended *informal homogeneous* substance which may be omnipresent in space. Any idea of *a beginning* in relation to this substance, implies its division into distinct parts, and the application of *number* to something capable of division, or to many things capable of combination.

Thus the ideas of *form* and *number* are contemporaneous in our minds, when applied to *matter;* but since the homogeneous basis (out of which the material *atom* must have emanated, if it were not eternally an atomic being) is assumed to be previously unlimited, or wholly without form,—we are really in the darkness of the incomprehensible world, so far as numbers can be applied to body, when we entertain the notion of an informal state of material existence.

Now it is under this imagined condition of material homogeneousness, that we may suppose the first manifestation of form to have taken place within any limited region of infinite space; and when we assume that the Intelligence of the great Mind of the universe caused the development of the various sorts of material forms, which we can perceive and analyse, we reason by analogy in speculating that ideas of form and number would have been made manifest in nature, in the same progression as that in which they are successively generated in our own minds.

The reasonable mode of applying numbers, in the first instance, to the division of a *totality*, would be to determine the quantity of primary parts into which it should be divided; and when this division creates different *formal* qualities, it is evident that our first notions of order would be materialised in our classification of dissimilar forms. Hence we should be consistent in supposing, that the *binary* and *quadruple* division would be developed, as fundamental conditions in the general arrangement of the material world, because *two* and *four* are our first numerical ideas.

Another practical application of ideas of quantity may be to a division of the whole period of *time* assigned to any general physical operation or connected series of operations. This sort of division is connected with the notion of a *passing period* of time, which was not the case in the other. The six days of the Mosaic cosmogony, and the three distinct stages of insect life, convey an idea of a succession which does not necessarily accompany the contemporaneous division of a class of animals into species, genera, or orders.

A third mode of considering numbers in reference to things, is the determination of the quantity of such things which are to be brought into relation to each other: this includes all corpuscular or corporeal combinations, as well as systems of stars or planetary bodies.

A fourth mode of application, is to determine *how many* similar or dissimilar organs should be assigned to, and *how* they should be distributed in or upon, the same body: the study of vegetable and animal physiology is an enquiry into the functions of such objects of number and form.

It will be found that the proportions in every case tally with the assumption, that certain numbers were preferred to others, when the idea of any physical phenomenon was made manifest, and that the *mathematical age* or relative seniority of each *formal* number determined its application in the natural order of the world.

CHAPTER III.

ON THE SELF-SUGGESTED *CIRCULAR* ARRANGEMENT OF NUMBERS, WHICH ARE INSCRIBED IN GROUPS IN THE ORDER IN WHICH THEY ARE FIRST OFFERED TO THE HUMAN MIND BY THE MATHEMATICAL PROCESS OF ATTAINING SUCH IDEAS.

SECTION I.

On the division of the series of mathematically-generated numbers into two distinct groups or categories.

In the first attempt to derive our ideas of numerical proportion from the ideas of form, which are created in the human mind by the exercise of its mathematical faculties, we find that there are two sets of numbers.

The whole series, 2, 4, 7, 1, 6, 3, 4, 5, 2, are the offspring of our meditation upon the division of a single circle and upon the combination of seven circles: but 3, 4, 5, 2, also offer themselves to our reflection as the numerical results of the simplest mode of spherical combination, and therefore they belong to a distinct category.

We are justified in adding *eight* to this group, because that term of quantity holds the same relations to the spherical form as *four* does to the circle: the eighth part of a sphere is the counterpart of the fourth part or quadrant of the superficial circle, and in that character it may be treated as a *fractional* denominator, belonging to the category of spherically generated ideas of number. But as it can have no place in the category suggested by the *septuple* combination, we should be inconsistent in arranging it before 3, 4, 5, 2, in the general series, upon the principle which induced us to commence the series with the circularly-developed fractional numbers 2 and 4. The general harmony would be broken by such an interference.

Independently of this consideration, it must be remembered, that the method of bisecting the sphere horizontally, by bringing down the original straight line or polar axis to its equator, and by then imagining its revolution on its central point to occur in a new direction, implies a method of complicated mathematical construction, which is hostile to the self-suggested alternation of rest and motion previously assumed to be our basis-principle. This has been already noticed (see p. 13) as a difficulty; and we have been obliged to reject the hypothesis, that the cubic combination of eight spheres in contact, can hold rank among the simple modes of agglomeration of spheres, because that arrangement supposes the existence of an aboriginal adjustment, offering a greater waste of space than that which appears in the triangular interstices of the septuple combination, and therefore a less compact distribution of the spheres than that attainable by such a mode of bringing them together.

Hence it appears, that although *eight* is an indicator of fractional proportions, the idea of that number is not created by a simple method either of mathematical division or combination, and that if it be treated as the offspring of a *formal* process, it should be placed in the last position in the series of mathematically-suggested ideas of proportion. But it is the first number generated by an arithmetical process, whether we consider it as the product of *two* and *four* (our earliest mathematical numbers) multiplied into each other, or as the result of applying the principle of *duplication* to the most harmonious combination of spheres having four constituent parts, four equal sides, and four similar angles.

Thus *eight* may be regarded as the complementary number of the limited spherical category, 3, 4, 5, 2, or of the whole series of mathematically suggested ideas of quantity.

The two groups, distinctly separated from each other upon these grounds, will each consist of five numbers, and they suggest a new mode of *spacial* arrangement, in which the *things* to be classified are no longer ideal *forms*, but ideas of *number* represented by points. Our method of representing these numbers by cyphers gives them perceptible forms; but they may be treated as informal ideas, for our ideas of terms of proportion and of cyphers which represent them formally, are altogether distinct from each other.

Now, bearing these premises in mind, let us endeavour to combine our conceptions of form and number. As the circle is the first and simplest enclosure of a portion of infinite space, which we are capable of conceiving, and its divisions into semicircles and quadrants are productive of our first numerical ideas, we are warranted in the attempt to discover, how far it may be possible to arrange our two separate groups of numbers in circular tables.

There are five obvious points in the quadrated circle,—namely its centre, and the four ends of its two diametrical lines, which, bisecting each other at right angles, are nevertheless of different ages in *the conception which imaged the circle.* The first repose of the straight line, which produced the circle when in motion, offered the figure of the semicircular bisection; but another interval in time was supposed to be requisite for the renewed motion and repose which divided the semicircles.

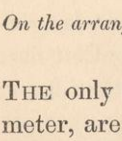
Thus we can conceive the two diameters of the circle which they divide into quadrants, to have different qualities, although in appearance they are exactly alike: the specific difference is that *of age*, which has marshalled our series of numbers in their respective grades; and it should be remembered that this quality of precedence or seniority of one diameter in relation to the other, *is imperceptible to the senses* in the complete quadrated circle; although it is the basis of all formal differences, as will be explained hereafter. The eye will never inform the intelligence of the relative ages of any coexisting radii of a circle.

In the sphere, the *axis*, upon which that form itself is ideally dependent, can never be mistaken for an equatorial diameter. Although it may be supposed to change its own position from one part of the circumference to the other, it always remains the regulator of the other lines described within or upon the circumference of the sphere, and the two ends of the axis are its poles. Such is not the case with the circle; but we can understand why the superficial circle, constructed ideally as we have constructed it, should have a polar and an equatorial diameter, notwithstanding the absence of that peculiar and obvious property of the axis diameter, which is *perceptible* in the sphere. The polar diameter of the circle has no axis-property; but it is capable of becoming the axis, and it is impossible to conceive a more beautiful development of the ideal generation of form, than is observed in the alternations of movement and rest, affecting that formal distance between two points, which is called the line. Its first activity produces the circle; its rest the two semicircles, between which it appears as the polar diameter: if it be again moved and again ceases from moving, it leaves behind it the representation of its first form of repose, which is always the polar diameter, and creates a new general form, that of the quadrant; but if the ideal motion be transferred from the diameter to the circumference of a superficial circle, and the idea of a sphere be thereby imaged to the mind, the diametrical line in question is at once converted into the axis of such a sphere. In this condition, however, it has no other properties, because another transfer of motion is necessary, before that diametrical line can be the sector of the spherical region of space in which it would otherwise be a quiescent axis.

SECTION II.

On the arrangement of the primary numbers 2, 4, 7, 1, 6, *in the form of a circle.*

THE only self-evident points in a circle bisected by its diameter, are its poles. If we connect our two first numerical



ideas with these formal notions of fixed points in a circle, we proceed consistently in supposing relations to exist between our earliest ideas of proportion and the two ends of the original diametrical line: and this method of localising numerical ideas is reasonable, when we have obtained a notion of definite points in space, however high such numbers may be, because the idea of a high or low quantity may be represented in the mind by a single point, when it is considered in relation to space, as ideal numbers themselves can have no formal qualities.

The first result of this application of different numbers to similar points in a circle, is the creation of a new idea of comparison, or of superiority and inferiority, as regards those points, which would not be attainable by any other method; because our whole system of progressive development is based upon the *aboriginal existence of both points.* The superiority has nothing to do with the high or low quantity expressed by numerical terms, but it depends upon the order in which they were respectively conceived in the mind. According to our method of accounting for these mathematically-originated numbers, *two* precedes, or is older than, *four*: therefore the same reason which makes one diameter of a quadrated circle older than another, attributes a borrowed seniority to the end of the original diameter, to which we attach the cypher representing *two*; as opposed to that with which we connect the idea of *four.*

When we combine this notion of localising 2 and 4, with that of a progression in time, which is intimately connected with their conception in our minds, and of the linear form in space which unites the two points of a bisected circle—we are enabled to formalise an activity in space, which is altogether distinct from *locomotion.* We figure to ourselves a current of influence *flowing* along the diameter from the point attributed to 2, to that in which 4 is posited, without imagining any formal movement in space at all resembling that first ideal motion of the two points, which generated the idea of the circle's circumference.

It may be shown that the abstract idea of *fluidity* can be obtained without meditating upon space. The *present moment* in time is the counterpart of *the point* in space; both are representatives of the infinitely *minute*, in the same way as infinite space and eternal time are those of the infinitely *vast.* But the *present* moment cannot be comprehended practically, unless it be treated as the *passing* moment in relation to the medium of time, and considered as the past, or future, because it is inappreciable in its own absolute character as the *present*. *The present moment holds no relation to our idea of duration.*

Now, when this truth is duly estimated, it will be found that the most elementary idea of *abstract motion* is that of a perpetual current of the present flowing into the past, and therefore only moving in one direction; and that such an idea is wholly independent of all *spacial* conditions. Hence it appears that fluidity in the abstract requires no locomotion of points, and no *formal* basis for its development in our imagination; *it is already conceived in the mind, before we meditate on the formal results of the motion of a point in space*, and it may be practically applied to the line which connects two points.

We cannot imagine any other mode of formalising this notion of an abstract progression, than that of connecting it with our idea of a limited straight line, or of a circumferential line which encloses a limited portion of space. Having done so, we may either suppose that *its influence passes along* the diameter of a circle, or that it accompanies its circumference, without interfering with the lines themselves in either case. Should there be no difference between the two ends of the circle's diameter, we conceive the idea of two such abstract currents crossing each other, or of a reciprocity between its two final points: but if we invest one of these points with the quality of superiority over the other, which is implied by one of them being a locality of the first number *two*, while the other is that of the second number *four* (the superiority depending upon one number being conceived by the mathematical process of generating numerical ideas, *before* the other), *the progression suggested by precedence in time may be transferred to points in space*, and the evenness or uniformity of the two imaginary currents is interfered with. We therefore attain the idea of a *major* current in one direction, and of a *minor* current in the other, by this method of combining our earliest notions of form and number.

But if we dismiss from our minds all ideas of reciprocity between the points, and content ourselves with combining the primary notion of abstract fluidity *in one direction* suggested by the *present constantly flowing into the past*,—and proceed at once to apply this notion of progression to the diameter of the circle, the ends of which are connected with the successive numbers *two* and *four*, whose mathematical development offers another sort of progression in time,—this combination vivifies (as it were) the diametrical line with a sort of influence *flowing in one direction only*, from the older to the younger number, or from the point denoted by 2 to that on which we have posited 4. (*a*)

The importance of this consequence of combining our first ideas of number and form will be more fully understood, when we endeavour to construct a chain of circles, and to make their united polar diameters represent a continuous current of this description, which will formalise the idea of a progression in only one direction.

No notice has been taken of the central point of the circle in the above remarks; because, although it must have been in existence, as the pivot or fixed point upon which the straight line rotated when the form of the circle was imagined, it is not designated when the cessation of that rotation leaves no other formal image than the circumferential and diametrical lines. In that condition of the newly-developed figure, the place of the central point can only be ascertained by artificial measurement: for the only apparent points in such a case would be those at the end of the diametrical line.

(*a*) In its abstract character, the progression suggested by the *present* flowing into *the past*, does not offer the idea of reciprocity which arises in our minds, when it is referred to two points in space, or to the two similar ends of the diameter of the circle. But as soon as the single progression is considered in relation to form, we attain the conception of a reciprocity between two points, or of two currents *crossing each other*; when this idea is materialised, *reciprocity* becomes one of the primary or basis conditions of physical activity.

It may be demonstrated that this abstract idea is materialised in the physical world. Electrical or magnetic *induction* is not a phenomena of *locomotion*, but of a reciprocal activity between two distinct entities, in which there is the propagation of an influence in space, not necessarily attended by any change of place of the objects so acting upon each other.

But when a *second* rotating movement of that line has left it at right angles to its previous position, the centre of the circle is self-evident, and three other points may be determined. The new position of the line also suggests the idea of a formal opposite: while the pivot point symbolises the abstract notion of a mean between the *two contraries* of a *polar* and an *equatorial* diameter.

This notion is in exact accordance with the relations of the remaining three numbers of the first set, namely, 7, 1, and 6. They were suggested by the formal *combination* of seven circles so placed that *one* was the centre, and *six* were in the circumference of a figure: but 2 and 4 were suggested by the formal division of one circle, or by *breaking an integer into fractions*, which is precisely the opposite idea to that of *combining integers*.

Seven, the indicator of the totality of the combined figure, is the opposite of *one*, the indicator of its central circle in a septuple combination; but *six* is the mean between 7 and 1, both by addition and subtraction, and between 2 and 4 by addition. Hence the *points* of the equatorial diameter, which correspond with the poles of the original diameter, may be attributed to the ideas of 7 and 1, while the central point is the evident locality of the ideal 6.

We have thus constructed a circular numerical table, having two diameters, and formalising many ideas which are typical of contrariety. The polar ideal current is the opposite of the equatorial current: that proceeding from pole to pole, would seem to flow uniformly in one direction and to be incapable of change: that from one end of the equator to the other, if considered as the emblem of numerical addition only, indicates the completion of a process (1+6=7), while the other seems to direct the search elsewhere *for the result*, although the *apparently accidental* harmony of the circular table places that result at the centre *afterwards*. The first contrariety is found in the difference between the arithmetical current running on to something else *beyond* the circumference *in the polar direction*, and the other which begins and ends *within* the circumference *in the equatorial direction*.

These two distinct ideas of the *complete* and *incomplete* arithmetical process, in relation to the limits of a circle, indicate, that the polar diameter is the type of a portion of a continuous system or current, which *flows out of the circle* at the point which we call its lower pole; and while the equatorial diameter suggests an independence of external things, the polar diameter appears to depend upon some other table in which we may expect to find a continuation of the descending current. The ultimate development of this inference will be the construction of a *chain of circular tables*, which are connected in the direction of their polar diameters, but necessarily unconnected with each other in that of their equatorial diameters. If, on the other hand, we regard the central 6 as the complement of the two polar numbers 2 and 4, we find an antagonism between this accidental form of inscribing the sum total in the centre of the circle as regards the polar diameter,—and the usual mode of placing it *beyond* its two constituent numbers, as regards 1+6=7 on the equatorial diameter.

The coincidence between the sum total of the numbers on the circumference, and that of those on the equatorial diameter, is indicative of numerical harmony, and

appears to justify the plan of thus arranging these five numbers in a circle: for 2+1+4+7=14 on the circumference, and 1+6+7=14 on the equatorial diameter. It should be remembered, however, that 14 is not a numerical idea inscribed in the circle, but produced by operations of the mind in dealing with the numbers so inscribed. Multiplication is not developed in this table; the harmony, however, which is expressed *in signs* is complete, as we find 2+1+4=7 on the circumference, and 1+6=7 on the equatorial diameter. Each semicircle is formally equal to 7: the numbers 2+1+4 (on one arc), correspond with 1+6 on the semidiameter with which the arc is connected, since it divides that semicircle. The other semi-circumference is either attributable to 7, or to 4+7+2=13, and the other semi-diameter is also 7, or 6+7=13.

SECTION III.

On the arrangement of 3, 4, 5, 2, 8, *in a circular form.*

The second set or category of numbers may be arranged within a circular form, as the first has been; but the mode of proceeding is so far different, that the central point of that circle and its equatorial diameter may be supposed to be contemporaneous with the polar diameter, because the idea of the *complete* first figure is already in existence as a general model, and that of any other subsequently imagined similar form stands in need of no *progressive* process of construction in the mind.

In accordance with this hypothesis, we do not commence by supposing a necessity for at first dividing the second circle

into two semicircles, and, for locating numbers at the two poles, before we place a cypher at the central point; but we proceed at once to inscribe 3, 4, and 5 upon the polar diameter. The places of 2 and 8 are self-evident at either end of the equatorial diameter: and the central point is again occupied by a central number or one common to both diameters.

The development of a new contrast is remarkable in this numerical progression: 3, 4, 5, constitute an arithmetical series, while 2, 4, 8, denote a geometrical one; and both these modes of progression differ from those of the first circle, in which 2 and 4 were polar numbers, with their sum total 6 midway between them by subsequent accident, which would have been altogether wanting supposing the equatorial diameter had never been drawn; while 1, 6, 7, the terms of a complete sum in addition or subtraction, appear upon that diameter without suggesting the idea of multiplication or division.

The subordinate division of the set of numbers into the two or perhaps three separate sections of 3, 4, 5, and 2, and 8, or at all events into 3, 4, 5, and 2, 8, is coincident with that of the first circular group, which also consisted of two sections, 2, 4, and 1, 6 7.

As regards those numbers of the second group which were suggested by circular combinations, 3, 4, 5, are distinct from 2; but 8 is an arithmetically created idea. Hence 3, 4, 5, hold relations to each other in spherical combination, because 3 is the basis of the solid combination of 4 spheres, whose tangents form the equilateral triangular solid, and 5 is the number of spheres which constitute the solid of a double triangle. But as 2 is typical of *a process* in this case, and not of a distinct *form*, it is on the other diameter of the circle, because it is an indicator of the *two-fold* operation which converted the *superficial* triangular arrangements into the *double solid* triangle, while 4 and 5 are each indicative of a new *form* attained by adding one sphere to the previously existing 3 or 4. The position of 3 and 2 in relation to 5 in the circle, is beautifully explicative of that idea.

The two circles contain properties which suggest another most important contrast: the first circular table must be the representation of an entirely new system: its origin is one of abstract form, and it is almost independent of all preceding ideas of the same description. Not so the second table, whose circular *form* is the mere copy of the first, and it may be followed by others in a continuous chain of tables having similar forms. Besides *the second circle* of numbers may be in relations of contact to *two* other circles, *the first* and *the third;* while *the first* is only in juxtaposition to *one* other group of numbers, *the second:* and it is evident, that this difference in their conditions of contiguity is connected with our ideas of a beginning as well as of a model. The *third* may be constructed on the same plan as that of the second, because they may both be referred ultimately to the idea of a beginning, which makes the first a *model* of every subsequent *formal* arrangement of cyphers in a circle.

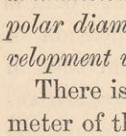
In any continuous series of such groups, the first *form* of the quadrated circle, independently of numbers, is the model of every *subsequent lineal* form in the chain; it is the formal beginning of the concatenation of cyphered circles; but the numbers of the second circular table (with the exception of

8) are like those of the first table, *mathematical* creations of the mind. The general idea of arranging them in a quinary mode is part of the model-idea of form belonging to the first table; but *what numbers were to be so arranged,* depended upon the existence of the series, 3, 4, 5, 2, and 8, which was a fact altogether independent of 2, 4, 7, 1, 6, being previously arranged as they are in the first circle.

Now, as the whole series is exhausted in the construction of the two circular tables, the second table is more likely to be the exact model of the special method of arranging *numerical* relations in subsequent tables; and the difference between the other links of the chain, or between them and the second, may be expected to be an *arithmetically* created difference, because the *mathematical* progression is completed in the second circular table. When we construct a series of such numerical circles upon the model of the second, we find an *arithmetical scheme of numeration running down the line of polar diameters,* and a *separate* and distinct *geometrical development upon each independent equatorial diameter.*

There is no idea of multiplication in the equatorial diameter of the first circle: $1+6=7$ is the antagonist numerical idea of $2\times4=8$, both being on the equatorial diameters; while 2, 4, is the contrast of 3, 4, 5, on the polar diameters. *Multiplication* and *arithmetical progression* are new ideas developed as numerical *emblems of operations in time* in the second circle and not in the first; for the adjustment of fractional parts of a whole, originally imaged by the division or subdivision of unity, does not convey the idea of multiplication, until it is accompanied by the development of an arithmetical succession.

The first circular table is constructed without the imagined assistance of the spherical form: in its polar direction it is



numbered in accordance with the division of the single circle into semicircles and quadrants, which are the leading forms generated by such a division; in its equatorial direction it is numbered in accordance with the septuple combination of circles, and the obvious division of that combination into a central and a circumferential portion. Thus the five cyphers inscribed in the first table represent leading formal ideas of a most simple character, which are generated by our meditating upon a superficial circle, and a superficial combination of seven circles.

But the second circular table is constructed by using a series of numbers which follow each other in the same succession, 3, 4, 5, 2, whether they grow out of the

septuple combination of circles, or the three distinct forms of spherical combination. If we regard them as the creatures of our meditation on spherical combination, we give the second circular table a much more complicated character than we assign to the first. *Three* is the numerical sign of three spheres in triangular contact, but such a combination is not productive of an idea of solidity: it is true that the sphere itself may be called a solid: but that the elementary atom in the material world is solid, seems very problematical. Yet the complication of *three spheres* in superficial contact is different from that of three *circles* in a similar contiguity; and it offers the *transition-idea* between our notions of superficial and solid properties in the abstract.

Solidity, however, cannot be treated as the necessary property of a combination of spheres, until *four* spheres are in contiguity, as they must be, when *three* spheres are placed under or above *one*, which would be in contact with them all: but supposing a fifth sphere were placed on the other side of the original triangular space between the three, and *opposite* the fourth sphere,—in that case *five* would be the numerical term suggested by such a combination.

Thus the two numbers 4 and 5 are both emblematic of the idea of similar operations, and in that respect they differ from 3, which accompanies the transition-idea of something between circular and spherical combination. *Two* and *eight* are both originated arithmetically in the series, but two only has reference to a combination of integers in this table; because it is the number of a distinct quantity in a combination consisting of distinct spheres. In the septuple figure *one* was the arithmetical idea suggested by the central circle; in the combined solid of *five* spheres, 2 is the sign of the quantity added to the original transition form of three spheres. Hence *two* may be itself a sort of secondary or contingent term, as regards the class of numbers which are generated by mathematical ideas of form.

Finally, *eight* is both a mathematical and an arithmetical conception; that number does not express the sum total of the constituent integral parts, of the *septuple* combination of circles, or of the *quadruple* and *quintuple* solids of spheres. Eight, therefore, the *first arithmetical* number (according to our progressive method), is the *last* cypher in the second table, and connects it with all the subsequent arithmetical conceptions of the mind, which seem to be capable of extension in an infinite series. The appearance of *eight* in this circle is most appropriate, and in perfect accordance with the whole hypothesis: it connects the second circle with the third, as *three* connects the second table with the first; both 8 and 3 are transition numbers; 3 indicates the transition from superficial to spherical combination, or from superficial ideas to those of solidity: 8 marks the change of process from the *formal* to that sort of *arithmetical* meditation in which human reason *practically* exerts itself, when busied with numerical conceptions.

Thus the only two numbers in the second table, which belong to the same order, are 4 and 5: but we have already seen, that the form which produced the idea of 4 in this instance, is more regular and harmonious than that which suggested 5. Four spheres, four equal sides, four external angles, convey a much more complete notion of a general type than five angles (of which two differ from the other three) and six sides; moreover as one diameter of the quintuple combination of spheres is longer than the others, the solid figure thus produced is connected with *uneven* general conditions, which are not found in the combination of four spheres.

Furthermore, as the place of 4 is at the centre of the circular table, which location did not arise from any of the above considerations, we cannot avoid being struck with the abstract fitness of this sign of quantity for such a position. A new class of things is brought under our consideration, when we meditate on spherical combination; and a little reflection will satisfy our reason that until we arrive at that stage of thought, we are unable to connect our ideas of *material* existence with those which we conceive of *form*. Let the materialist be as dogmatic as he pleases, he is unable to gainsay the proposition, that the whole class of *formal* ideas, which are connected with *superficial*, but divested of *solid*, qualities, are entirely independent of our ordinary notions of material conditions; while all material properties and qualities which he can conceive, must be based upon them. This is still more evident when we suppose the chemical atom to be a hollow sphere. The second circular table is the first numerical representation of such a basis; and *four* is the number which appears there,—and is suggested by other formal considerations, as the most complete numerical type of material combination.

The nearer relationship between 4 and 5 in this table, than between any others of its numbers, will be found to coincide with an arithmetical progression in other tables; their central and *lower* polar points, will always be the places of successive numbers; and we shall find 6 and 7 similarly placed in the third table,—8 and 9 in the fourth,—10 and 11 in the fifth, &c.

Thus the numerical type at the centre will express the double of the number, which is that of the table in the series, in all groups except the first. We are not justified in expecting to find the same sort of harmony in the first numerical group: but as there is an evident connexion between that group and the second, and between the second and every subsequent group, this difference in the method of arrangement of the first and second groups, does not interfere with the general harmony of the whole progression.

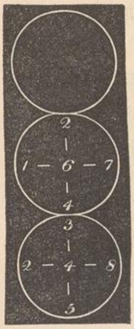
CHAPTER IV.

ON THE SELF-SUGGESTED CHAIN OF NUMERICAL CIRCLES.

SECTION I.

On the formal application of the idea of a beginning to a series of numerical tables, when that idea is represented by the undivided and uncyphered circumference of a circle.

THE three most obvious coincidences in the arrangement of the cyphers of our two circular numerical tables are found in



the numbers placed at the upper poles of these circles, and at both extremities of their horizontal or equatorial diameters.

The upper polar number in the first table is 2: in the second table it is 3. The left hand equatorial number in the first table is 1: in the second it is 2. The right hand equatorial number in the first table is 7: in the second it is 8.

These three striking instances of an arithmetical progression indicate, that the groups are first and second in relation to each other; but the appearance of 2 at the *upper* pole of the first circular table, and of 3 in the same place in the second, imply that there may be some antecedent circle in the ideal series, which will be the first symbol of form, and the mathematical coincident of 1 in its character of an emblem of undivided unity or totality.

The blank circle is in every respect the formal type of this idea. According to our hypothesis, no sign of proportional quantity will represent unity. There can be no apparent pole or point in a circle where there is no diametrical line; and in the first idea of the activity which describes the circular image, the diameter in motion is (as it were) invisible to mind's eye. Its *rest* is a condition necessary to its manifestation as a bisector of the circular area: although the idea of a bisection once developed, *remains in the mind after the diameter has been again moved* from the position within the circle, where it was first supposed to have been *at rest*,—still, that *first* cessation of motion was indispensable in order to suggest the idea of a diameter in relation to the circumference.

Hence it follows, that we are justified in conceiving the idea of a circle, undivided by any diameter, as the first image of a complete enclosure of space; and such being the case, we thereby attain no notion of a point on its circumference, or within its area, on which a cypher should be inscribed. Our image is in itself an integral and absolute unity; it suggests no numerical idea of relative quantities, of the practical division of an integer, or of the combination of integers.

Supposing such a blank circle to be the first emblem of a limited region of space, the first circular table of *numbers* must be considered as *a second* in the general succession of *formal* images, while the *second* table of *numbers* becomes a *third* in the succession of similar *forms*. But the *second* in this *formal series* develops original attributes of form, because although it repeats the circumferential *outline* of the blank circle, and thus far is but the copy of the first, yet it demonstrates the newly generated ideas of the diameters and radii of the semicircle and quadrant, as well as that of the central point,—which five novelties are not apparent in the circumscribed circular space at the head of the series.

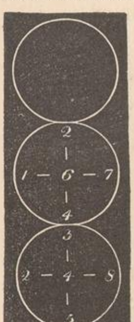
Hence it follows, that the three different ideas *of a beginning*, which are suggested by meditating on the causes of physical phenomena, (and are connected with the existence of an aboriginal informal ether, or homogeneous material substance without form,—of divisions of that substance into distinct atoms, and the consequent development of form,—and of the manifestation of solid qualities in consequence of the combination of these special material entities,) are symbolised by our three circles. The blank circle represents the totality of the material universe. The first cyphered circle is a symbol of the double process of its division into parts, and of that *general* succession of physical phenomena in relation to periods of time, which is connected with our abstract ideas of the *gradual development* of classes, genera, and species. The second cyphered circle is an emblem of practical solidity or of compact combinations of material atoms. This method of referring such mathematically generated ideas to the physical world, is warranted by our experience in chemical analysis, and physiological observation. But such an application of the general hypothesis must be deferred, until the abstract harmony of the numerical system has been more fully investigated.

SECTION II.

On the ideas of harmony which are suggested by the arithmetical consideration of the cyphers inscribed in the two first circular groups of numbers.

Notwithstanding the different modes of constructing the two tables in which we have inscribed the mathematically-originated numbers, these tables are almost counterparts of each other, and they develop an antagonism of so regular a character, that we infer the existence of a most intimate relationship between them.

It has been already shown that the first table contains no continuous arithmetical or geometrical succession, while the second table exhibits them both. As regards form and number, this is in itself the manifestation of a decided contrariety, but the antagonism is still further demonstrated in the relations between the numerical values of the cyphers which are located at their corresponding poles. Where the numbers are *odd* in one circle, they are *even* in a similar position in the other : 2 and 4 in the first table are represented by 3 and 5 in the second ; while 1 and 7 in the first are in the position occupied in the second by 7 and 8, which arrangement, when viewed *laterally*, develops the double arith-



metical progression of 1, 2, and of 7, 8, on each side of the compound figure. (*a*)

Although the numbers on the coinciding diameters of the two circular tables differ to such an extent, they offer similar sums total. 1+6+7=2+4+8=14, and 2+6+4=3+4+5=12. Yet the five numbers of each circle produce different totals; because 2+1+4+6+7=20, while 3+2+5+4+8=22. This unexpected result is owing to the quantity expressed by the central cypher in each circle, which is larger in one than in the other. Hence the difference is to be attributed to a change in the formal relations of the cyphers inscribed on the two diameters of each circle: when the central numbers are reckoned twice, each polar diameter offers a total of 12, and each equatorial diameter gives a total of 14, so that each entire group would, under such a *formal* method of computation, suggest the idea of 26; although the ordinary *arith-*

(*a*) It will be found in a subsequent part of the work, that there is always a harmony between 1 and 7, and that the abstract progression which is constantly paramount, depends upon both 7 and 1 being terms of unity. This truth is of course to be traced to the original relations between the single circle and the septuple combination of circles which most resembles it; for both these formal ideas were concerned in the creation of the series, 2, 4, 7, 1, 6, 3, 4, 5, 2. The new progression based upon the relations between 1 and 7 advances by sixes, in the following order,—7, 13, 19, 25, &c.; in the complicated combinations which will be presented to the reader in the next chapter, he will always observe a harmony depending upon a comparison between tables, or links in the chain which hold this relation to each other.

Another important truth is demonstrated in the above formal arrangement of the four numbers 1, 2, 7, 8,—namely, that as the second table is the symbol of practical combination, where 1 or the term of unity is replaced by 2, and 7 is replaced by 8,—the actual progression commences with 2, and advances by sixes, as 8, 14, 20, 26, 32, 38, 44. The result of this method is, that the octave of 2, in such a progression, is 44: and it will be proved hereafter, that there is a natural relation between 4, the central number of the second table (the term of quantity in regard to the most perfectly harmonious combination of spheres), and 44; so that our convenient and artificial mode of enumeration by units, *tens*, hundreds, &c., can be shown to be *abstractedly* the most perfect. This truth will be demonstrated in many other cases: the *ten-fold* mode of increase will be exemplified still more wonderfully by the *formal* arrangement of circular numerical tables, which are constructed on the same model as the second group now under consideration, where 66 will be developed as 44 is in the present instance. But it would be perplexing the reader to enter upon this question before he has had an opportunity of studying the more simple truths about to be advanced in this and the next chapter.

metical mode of adding together the cyphers in each circle would develop the ideas of 20 and of 22.

This difference between the results of a formal and arithmetical process of computation is interesting, because it symbolises the seeming paradox of the absolute or *arithmetical* truth being opposed to the apparent or *formal* truth. It will be found that similar contrarieties are materialised in the physical world, and that a *formal* mode of producing a basis-idea of number is as dominant in the laws of chemical proportion as the arithmetical mode is.

The motive, for instance, which seems to have determined, in nature, that a chemical particle should consist of twenty-six ultimate atoms, might be attributed to the model idea suggested by the *formal* mode of considering the numbers inscribed upon both diameters of a circular group, instead of computing them according to the *arithmetical* mode of simple addition, without reference to their respective positions in the circle.

As the two quadrated circles are exactly alike, in so far as their formal relations are concerned, even to the extent of containing the same totals on their corresponding diametrical lines, while the simple *arithmetical* ideas suggested by the totals of all the numbers in each entire group differ from each other,—we must regard these two cyphered circles as the symbols both of similitude and dissimilarity.

The similitude depends upon the form of the quadrated circle, and its diameters,—the dissimilarity upon that of the undivided circle without a diameter, which is the original formal basis of the most simple enclosure of space. Therefore the *older* formal idea is connected with that of abstract *dissimilarity*, when one of these groups of numbers is compared with the other: and this notion is in harmony with the obvious result of imagining the existence of any *region* of space, distinct from infinite space, which is our first most complete formal idea of spacial *contrariety*. The mere *linear* form does not even offer the image of a *superficies*, although it also conveys the notion of a contrariety, when considered in relation to infinity; for the idea of a spacial *region* is not generated in the mind by the conception of a linear distance between two points.

Thus the harmony of the system now under consideration is gradually developed as we advance in our synthesis. The application of ideas of distinct *numbers* to those of form, is the counterpart of the application of *formal* ideas to that of space. But all our ideas of numbers are derived from forms, (as 1 is the numerical representative of a single circle capable of division, but as yet undivided, while 7 represents the form of circular combination the most resembling the original circle,—also a divisible form *as yet undivided*), these two numbers 1 and 7 are the counterparts of each other, both representing totality. It is therefore in perfect consonance with such a notion, that the *simple arithmetical addition of all the quantities denoted by the five cyphers in a circle* (without reference to the mode in which they are distributed within that form) *should be the arithmetical process corresponding with the simplest mathematical process of generating the idea of a circular circumference.*

Finally, the dividing mode of reckoning the cyphers *by threes*, because they are distributed on the diametrical lines of circles, which is a more mathematical method than that of adding together *all the five cyphers of each circle*,—is a process which holds a relation to the pure mathematical process of bisecting and quadrating the circle itself, and of considering the component parts of the septuple combination of circles, as separate integers.

Now, applying these premises to our figure of three circles, we may consider *the first* which images form without number, to be the basis of the system;—the second to be its copy as regards the circumferential outline, but to have original qualities as regards the divisibility of the area, and therefore to be the *first cyphered* circle;—the third to be the copy of the second, as regards all *formal* qualities, but to exhibit within itself the development of the new arithmetical power of multiplication, and therefore to be the beginning of a new subordinate series.

The second numerical table, *i.e.* the third formal circle, may therefore be considered the model of any succeeding groups of numbers, which are to be constructed upon pure arithmetical principles. Not only shall we find that a series of cyphered circles, which are constituted in accordance with such a model, offer surprising formal and numerical harmonies,—but that the first table of numbers holds a peculiar relation to them all, which is the counterpart of that of the blank circle to all other *formal* figures derived from it,—or of that of the numerical emblem of unity, be it 1 or 7, to every other idea of numerical progression suggested by our method, whether it be generated mathematically or by an arithmetical process.

It may also be proved, that this mode of considering numbers will develop a most powerful system of logarithms, of so varied a character that the value of the same cypher is different in each circle when compared with a common standard of proportion.

But the object which first suggested the enquiry is fully attained ; and it may be assumed by the observing naturalist, that this series of cyphered circles has been in the conception of the great ordainer of the physical world, as regards the chemical, astronomical, and physiological laws, in accordance with which all its phenomena are made manifest.

SECTION III.

On the method of constructing a continuous series of circular numerical tables, which commences with a blank circle representing the idea of spacial *unity, but which may be infinitely extended, when it represents an unending development of new* numerical *ideas.*

It has been already demonstrated that the cyphers in our *second* circular group develop a progression which is more regular than that of the first. Its polar and horizontal diametrical lines indicate the directions of two sorts of numerical succession: that of 3, 4, 5, is complete in itself as part of an *arithmetical* series; while the other, 2, 4, 8, is perfect as a geometrical one.

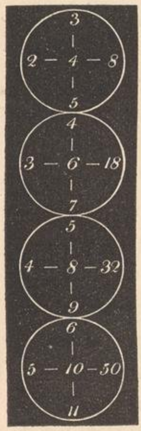
The horizontal succession exhibits an operation in multiplication which may either be the *duplication* of 2, and the subsequent multiplication of that number and the product into each other,—or the process of squaring and cubing 2. But no number except 2 can be so treated: if 3 be both doubled and squared, the result will be 6, according to one method, and 9, according to the other. Hence it follows, that since $3 \times 6 = 18$ offers the idea of *duplication* as a basis-principle which is more simple than that of *squaring* 3,—we are consistent in supposing that the *second* cypher in the *horizontal* line will always be the *double* of that to the left, and in preferring the series 3, 6, 18, or 4, 8, 32, to 3, 9, 27, or to 4, 16, 64, when we proceed to construct a chain of circular groups of numbers by adopting the second group as a model, and by applying *duplication as the first principle of power in a geometrical succession.*

The complete harmony of the second group cannot be repeated in any other group which may be constructed upon the same model; because the arithmetical *polar* series must be broken into two distinct parts, whether the central number be the double or the square of the left-hand horizontal number.

But the order of succession, as regards each entire group, is so self-evident, that any attempt to interfere with it, must be treated as an abandonment of the fundamental principles of our theory: the *upper polar number* ought to be the *formal* indicator of *the circle:* the *left-hand* equatorial or *horizontal number* should be the *numerical* indicator of *the group*. Therefore we are obliged to consider 3 as the *numerical* indicator of the third group, 4 as that of the fourth, and so on; but it will be found that when *the double* of that number is the *central* cypher of the group, it arranges itself in a regular arithmetical series, in combination with its *subsequent* polar cypher, and that that lower polar number holds a similar arithmetical relation to the central cypher of the next group.

Thus the *general* polar series in the chain, is confined to the central and lower polar numbers of each group; but the upper polar number (having its own special attribute as the *formal indicator* of *the circle*) is not to be reckoned in this general arithmetical series of the connected poles; it is the special indicator of each formal image in which all the five numbers of the group are arranged in relation to other similar cyphered circles which constitute separate links in the chain.

When the chain is constructed according to this method, the entire scheme is one harmonious system, complete in



itself as a whole, and capable of being considered as a concatenation of genera and species, each individual cypher of which is in its proper place as regards the cyphers in its immediate neighbourhood.

If, for instance, we add together the upper polar and the left-hand horizontal numbers of *the same circle*, or its *formal and numerical indicators*, the product will be equal to its lower polar number. 3+2=5. 4+3=7. 5+4=9.

When we add together the *numerical* indicators of *two adjoining circles*, the product will always be equal to the lower polar number of the *first* or *upper* circle. Thus 2, the left-hand cypher of the second group, when added to 3, the corresponding cypher of the third group, gives 5 as the product, which is the lower polar number of the second or upper of these two groups.

When we add together *both the upper* polar numbers of any contiguous circles (such numbers being their *formal* indicators), the product will be equal to the *lower* polar number of the second or *lowest of the two circles.* Thus 4, the *formal* indicator of the *third* group, added to 5, the *formal* indicator of the *fourth* group,—offers a total of 9, which is the *lowest* polar number of the *fourth* group.

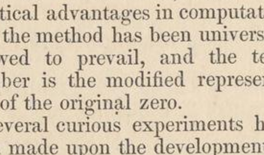
The *complementary* number of each group has peculiar formal properties of relation to the *other numbers of the same circle*, which offer an analogy to the relation existing between the *nine* original mathematical numbers, and the *tenth*, in the primary series. (*b*)

It has been already explained, that the complementary number of each group may be obtained by doubling its *numerical* indicator, and by afterwards multiplying it by the product,—a process different from that of cubing the number, because the original process is that of simple duplication, instead of the multiplication of a quantity into itself, or of squaring it. This mode of discovering the number which completes the circle, is justified by the following harmonies:

1st. It is equal to the total of all the *circumferential* numbers in the group immediately *preceding it* in the series. For instance, 18, the *complementary* number of the *third* group, is equal to all the circumferential numbers of the *second* group, which are 3+2+5+8. Or 50, the *complementary* num-

(*b*) Boethius informs us, that *nine* apices or characters were used by the Pythagoreans in their computations. The reason for this limitation of the quantity of figurative emblems of number, as basis signs, was considered a mystery from the earliest times: but the decimal system of arithmetic, in which the *tenth* term of quantity is the numerical representative of an integer, and the commencement of a new series, affords such practical advantages in computation, that the method has been universally allowed to prevail, and the tenth number is the modified representative of the original zero.

Several curious experiments have been made upon the development of 9, as the result of adding together, or substracting numbers from each other, when nine cyphers beginning with 1, and ending with 9, are arranged in an arithmetical succession.



In one of these it has been shewn that 10 is the perfect formalised complement of the whole series ; but this only proves that the number which is subsequent to the last in the series will be the general complementary term of the whole category. If there be but *seven* numbers, 8 will have similar properties. Therefore any attempt to fix upon 10 as a perfect number upon such grounds will be nugatory.

But in the chain of circles now submitted to the reader, the *decimal* system develops itself as the result of an arrangement in which there are 9 distinct mathematical creations of numerical ideas, without any arithmetical progression as to the mode of their arrangement; and it may be reasonably assumed that the mystery in question is nothing more than the fact, that there are only *nine* simple ideas of quantity attainable by this mode. Nevertheless, it is a fact of the greatest importance in an abstract system of numbers, and it appears to have been a basis-principle in nature, that such a self-suggested truth should have been influential throughout the physical world.

ber of the *fifth* group, is equal to all the *circumferential* numbers of the *fourth* group, 5+4+9+32.

2ndly. It is equal to the total of the three cyphers on the *horizontal* diameter of the preceding circle, when that total is added to the *upper polar* number of the group in question. For instance, 18, the complementary number of the *third* group, is equal to 2+4+8, (the cyphers on the *horizontal* diameter of the *second* group,) + 4: and *four* is the formal indicator of its own group. In the same manner, 50 in the fifth group is equal to 4+8+32, of the fourth group, when they are added to 6, the *upper* polar number or formal indicator of its own group.

3rdly. When these two harmonies are duly considered, it will be found, that if we *substitute* the formal indicator or *upper polar* number of a *succeeding* group for the *complementary* number of any circle—the *three horizontal cyphers* of that circle so changed, will offer a circle equal both to that of its three unchanged *circumferential* numbers, and to the complementary circle of the *preceding* circle; this coincidence establishes a new harmony between *three* neighbouring groups.

For instance: if we substitute 6 (the formal denominator or upper polar number of the fifth group), for 32, the complementary number of the *fourth* group;—the total of three *horizontal* cyphers, 4+8+6, will equal that of the *circumferential* cyphers, 5+4+9; and either of these combinations in the fourth group, will equal 18, the complementary number of the preceding or *third* group. (*c*)

(*c*) When the distinct groups are considered in relation to the atomic theory, it will be found that this method of substituting one number for another is frequently realised in the physical world; in those groups of the chain in which the complementary number is of a high value, it cannot be applicable to the quantity of *ultimate* atoms, which constitute each individual particle of simple substances: therefore, some mode of filling up the circle by substituting a lower term of quantity for the complementary number must have been resorted to, if it be a fundamental condition that each group should consist of five distinct sorts of substance. The idea of transposition is sometimes extended to other numbers of the group; but the basis of the harmony will always be found in some single link or circle of the chain; and the rules for transposing the numbers are few and simple. The fundamental principle in such a case is that of *opposite* numbers being the substitutes. Thus in the instance before us, the *last* equatorial (or the complementary) cypher on the *horizontal* diameter of one circle is replaced by the *first* polar number, or that at the head of the succeeding circle.

Such are the motives for constructing a chain of cyphers arranged in circular tables. The original type of the form of the table,—the quantity of cyphers to be inscribed in each circle,—the value of each cypher which is arranged in the circle,—and the relative position of each cypher so located, are all determined by a systematic method of mathematical reasoning. The fancy or caprice of the human mind is never allowed to roam at large during the investigation. Nothing is guessed at or taken for granted: a succession of formal images and of numerical ideas are gradually developed in the imagination: and the only postulates are, *space* and *time* as *media* of *action*, and *points* in space as the *objects* capable of being moved; while the idea of *motion itself* is accounted for as the offspring of our simple notion of the indefinable *now*, (the *present* moment,) *passing* into the never-beginning *past*. It is impossible to reason by a more searching method of analysis.

So perfect is the harmony of the chain of numerical groups thus constituted, that it is sufficient to know the position of any one cypher in a circle, or to name its denominator; all its other numbers are immediately suggested by the rules demonstrated above.

Supposing we wish to construct the 67th group: its *formal* indicator is 68: its lower polar number is 68+67, or 135. Its central number is formed either by doubling its *numerical* indicator, or by considering it as the predecessor of its lower polar number, 135, in a retrogressive arithmetical progression; and it is 134. Its complementary number is produced by multiplying the numerical indicator and the central number into each other: $67 \times 134 = 8978$.

It follows, therefore, that the chain may be continued infinitely, although it must have a beginning; this idea coincides with the notion suggested by regarding the *present moment* in time as the commencement of a progression in the abstract, when we consider *now* in relation to the *past*. But such an infinite extension cannot be referred to our notions of spacial *form*, or to bodily *locomotion* in space, because we commence our series of formal developments by supposing points to be at rest and incapable of generating any formal idea in their *single* or individual capacities, until they are considered in connexion with ideas of motion, which are first suggested by the inevitable passage of the *single present moment* into the past.

A little reflection will satisfy us, that the *basis idea* of *a succession*, as regards the gradual development of *numbers* (derived from *form* directly or indirectly), *is one of time, not of space*, although the numbers themselves and their arrangement in the chain of circles, depend ultimately on our meditation upon *formal* considerations. The potential infinite nature of the chain in *one direction only*, is of the same limited character as that of the present moment, when considered in its relation either to the past or future; and this mode of limitation is the condition necessitated by its intimate connexion with our idea *of a beginning*, which must accompany every formal image, or series of such images. Notwithstanding the infinite quality of abstract progression as regards time, the succession is limited in one direction and has a beginning, when applied to the analysis of our formal ideas. (*d*)

(*d*) The above remarks may appear too metaphysical, but they demand the serious attention of the reader before he applies the theory of numbers which is advanced in this work, to the phenomena of the physical world. Matter in its *informal* homogeneous character may be considered the antitype of space; and activity, vitality, or the moving principle, which pervades the universe, may be an antitype of a continuously-passing moment. When these two typical objects of contemplation are brought together in our minds, in relation to points or regions of space, we attain ideas of formal portions of matter, which may be again referred to the passing moment as the ultimate type of their activity. But the abstract and infinite activity is, as it were, degraded and limited by its association with *spacial* conditions, and every number and group of numbers has its epoch or distinct period of duration, in relation to the general series of numerical ideas, which succeed each other in the imagination during the construction of the chain, or the gradual development of special numbers, out of which it is composed. Applying the analogy to the material world, in its fullest extent, we can imagine a beginning of every class, order, and subdivision of corporeal forms and qualities, *as well as an end*, and we are at last brought to a consideration of infinite space itself, as the universal medium of all corporeal phenomena. But we are not justified in supposing, that there ever was a period when the universal homogeneous substance was simultaneously *at rest;* therefore, our ideas of the chain are only applicable to distinct portions of that universal occupant of space.

Then, in regard to the *passing*

The end of the *formal* series is really connected with the completion of the first quadrated circle in the chain ; for every other subsequent circular form is its copy, so far as the mere *formal* arrangement of the five cyphers, attributed to each of them, is concerned. But the respective *numerical* qualities of the cyphers themselves are determined by their progressive development, which is dependent on a division of periods of time; and this accounts for the infinite nature of the advancing *numerical* series, which is connected with *formal* ideas *as regards its commencement*,—but which continues its progression, after the conclusion of the process, which suggested the original ideas of the two diameters, and of the consequent quadrants of the circle.

Therefore every circle except the first and second, is a mere repetition of an original form: but every subsequent group of numbers contains new arithmetical ideas; having direct relations to the infinitely continuous activity of the *present flowing into the past*. The fact of the series having a beginning, but no end, is thus accounted for: its beginning is connected with our ideas of *spacial* division, because the first numbers are generated by *formal* images: its subsequently infinite character is connected with our ideas of the unceasing continuity of a passing moment in time, when the series advances without being the coincident of new developments of form, or new divisions of the circular areas which constitute the links of the chain.

moment,—continuous motion, without the concomitant ideas of beginning and end, must be its constant attribute ; but if that be applied to the material universe as the type of a first principle of material activity, it becomes connected with formal conditions, involving the ideas of beginning and end. This may be considered in relation either to the whole universe or to parts of the universe. As regards the entire universe, it is connected with formal activity in some parts, and inactivity in others. As regards each part, the substance may be in activity during one period, and in its homogeneous condition during another.

Hence it follows, that the Buddist doctrines of succeeding epochs of rest and activity, with respect to distinct portions of the material world, coincide with our most refined metaphysical ideas ; but the notion of a beginning and an end is not applicable to the universe *as a whole*.

CHAPTER V.

ON THE PRACTICAL APPLICATION OF THE CHAIN OF CYPHERED CIRCLES TO ARITHMETICAL OPERATIONS.

SECTION I.

General remarks on the self-suggested methods of applying the series of numerical tables to the solution of complicated arithmetical problems.

HAVING explained the method of constructing a connected chain of circular numerical tables, we may proceed to consider how they may be applied, practically, to the phenomena of the material world. But before this is done, it will be advisable to prove that this numerical system is capable of developing a much more complicated harmony, than that which is obtained by comparing its *contiguous* circles with each other ; and it will be shown that the concatenated series is not merely a barren display of arithmetical coincidences, like some of those mythic tables of numbers which were held in esteem by the cabalists and gnostics of antiquity, but a perfect system of logarithms.

When each circular table is detached from the chain, with the object of connecting it with others in new relations of contiguity, its cyphers and their new positions will be found to suggest more complicated ideas of *formal* harmony. If, for instance, the *first* table be placed in a central position, and the six following tables be arranged around it, as the ring of six circles is in the original *septuple* figure, we shall discover a scheme of coincidences so wonderful, that we may be almost induced to forget, that we are dealing with the immutable certainties of arithmetic.

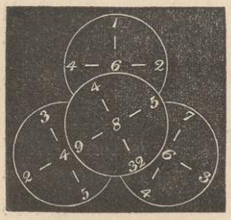
The same marvellous development of abstract harmony will be the consequence of our supposing each of these numerical circles to represent a sphere, and its polar number to be the value of the spherical axis, while the numbers on the circumference of the circle are transferred to the equator of the sphere. When the primary solid combinations of four and five spheres are imaged by the first four or five circular tables brought into the requisite contact, the result will be the manifestation of new coincidences still more astonishing; because the seeming accident of two cyphers originally distant from each in the chain being placed in *juxtaposition* in the new combination, will convert one of them into a *decimal fraction* as regards the other, —while the new term of quantity indicated by the two cyphers, will be equal to the sum total of several other cyphers which occupy some well defined portion of the same combination.

Although this mode of applying the chain to our ideas of solid combinations of spheres belongs to a more advanced stage of the theory, it may be cursorily adverted to here; because it leads to the development of a second chain, or a subordinate series of connected tables, in which the addition of the original number 7 to another number, holds an analogy to the first power of multiplication, which is that of *doubling* any given number.

SECTION II.

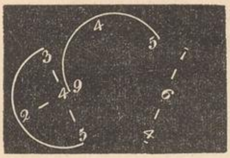
On the development of a new numerical table, whose constituent cyphers are suggested, by supposing the four first numerical circles to be combined in a figure, which is based upon the idea of four spheres being brought into contact in the form of the triangular solid.

If the quadripartite solid of four spheres be the formal figure, to which we apply the four first numerical tables, relatively connected in such a way, that the *fourth* be placed upon the interstice between the three others, (*a*) it will be found that 9, in that group, will hold such a relation of contiguity to 4, the central cypher of the *second* group, that together, they will offer the representation of the compound numerical cypher of 49.



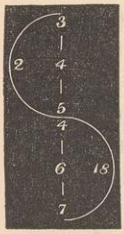
(*a*) The reason for this precise arrangement, will be explained in a subsequent chapter. The plate at the end of the next chapter may be referred to by the reader during his perusal of this.

This number 49 will equal the total of three sets of simple cyphers,—namely, 3 + 2 + 4 + 5, on the visible portion of the second group,—4 + 6 + 7 on the *diameter* of the third,—and 5 + 4 + 9 on the *semicircumference* of the fourth.

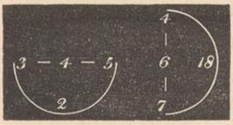


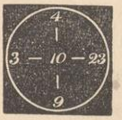
But if the diameter of the third, and the semicircumference of the fourth groups, be combined *formally*, the result will be the construction of a new semicircle: and when the cyphers on the semicircumference of the fourth group 5, 4, 9, are added together, and the product 18 is made a complementary number,—it will be equal to the complementary number of the third group, the compound cypher of which number is not visible in the figure.

Now as the cyphers 3, 2, 5, 4, are those of the *left-hand* semicircle of the *second* group, the *general* formal result will be the development of two semicircles containing eight cyphers, which are together equal to 49; and one of these semicircles will be on the *left-hand* of the second group, while the other will be on the *right* of the third group in our chain.



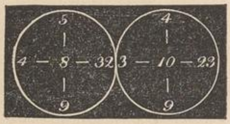
But when we change the relative positions of these semicircles, and combine them in such a manner, that the *polar* diameter of the *upper semicircle* shall be identical with the *horizontal* diameter of the *lower semicircle*, we attain the idea of a compound and *complete circular group* of cyphers. The central cyphers of the two circles 4, 6, will be combined, and their sum will be 10: the new lower polar number will be 9, in consequence of 2 being added to 7: and the new complementary number will be 23, or the total of 5 and 18. The formal indicator will be 4, as would be the case in the third group of the original series, and the new cypher the left of the horizontal diameter will be 3, as it is in that table: but as regards the other three cyphers of the new group, they must





be referred to the *fourth original* table ; 9, the lower polar number, holding the same position in them both, while the central number 10 is the substitute for 8, and the complementary number 23 represents 32.

When we compare this new table with the *fourth* group in



the original series, it will be found, that the totals of the cyphers on their corresponding left-hand semicircles, equal each other, for 4+3+9+10=5+4+9+8. But the difference between their complementary numbers, indicates a remarkable change in the *reversed* position of the simple component cyphers of 32, which are transposed as 23 : a change which develops as wonderful a numerical harmony, as that which converted the single cyphers 4 and 9, into 49.

When we meditate upon the internal harmonies of this new group, we discover that the total of the three cyphers on its polar diameter, is equal to its complementary number, because 4+10+9=23 ; while the same number 23 is attained by first adding 7 to the left-hand numerical cypher 3, and thus producing 10 (the central cypher) ; and by afterwards doubling that central number, and adding the basis number 3 to the product : 3 + 7=10, and 10×2 + 3=23.

Again, we find, that if we *square* 3 the basis-number, we have 9, the number at the lower pole ; and if it be *cubed*, the product is equal to the two remaining cyphers, or the circumference 23 and 4 : for 3^2=9, and 3^3=27.

This new circular table therefore exhibits a contrast, with respect to the mode in which the arithmetical and geometrical progressions are arranged within it, when it is compared with the tables of the original chain. In every numerical circle of that chain except the first, the *geometrical* progression is found on the *horizontal diameter ;* in this table it is on the *circumference.*

SECTION III.

On the method of constructing a secondary *chain of circles, in which the first formal blank circle of the original chain is represented by a numerical table having* seven *as its numerical indicator.*

It has been already demonstrated, that the numbers 1 and 7 hold relations to each other throughout our system, and that the idea of *unity* is intimately connected with the first idea of number which is generated in the mind by the most compact combination of *seven* equal circles.

Now supposing we construct a new chain of circular tables with the new group described in the last section as a model, we find, that when 7 is a constant quantity to be added to that cypher in the groups of the original chain, which has been termed its *numerical indicator*,—the central cyphers of the groups constructed in accordance with such a method, will exhibit a regular series of numbers in an arithmetical progression. This was not the case in the original chain, because two successive numbers in an arithmetical progression were formed on the polar diameter of each of its circles, and the central numbers advanced by *twos* : the central number of the second group there was 4, that of the third group was 6, and so on. Hence we are justified in calling the central number of each group in the *new* series, a numerical indicator of that group. (*b*.)

The two leading harmonies of the new group, are:—

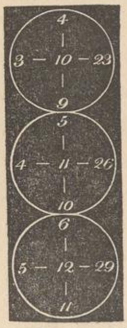
1st. An equality between the sum total of the three cyphers

(*b*) As the idea of this new chain is derived from the combination of *spherical* forms, while that of the original chain depended upon our notions of *superficial circles*, it becomes necessary to change the place of the polar diameter, and to convert it into an axis; and we shall be acting consistently in supposing the central cypher of a circular group, when applied to a spherical form, to be *an axis number*, while the four other cyphers will be on the equator of the sphere. In a subsequent chapter it will be shown, that when the *central* cypher is thus treated as the *axis number*, a peculiar class of harmonies will be developed, which cannot be otherwise attained. The central cypher of a circle in the *secondary* chain, being in reality the substitute for both the horizontal and the polar diameters of a circle in the original chain, according to this method of changing the place of the primary straight line which was the basis of all our formal and numerical ideas,—we are obliged to consider it as an *indicator* of the group which represents a sphere.

on the diameter, hitherto called the polar diameter, and its complementary number. Thus, 4+10+9=23.

2ndly. An equality between the complementary number, and another combination of cyphers, in which the left-hand horizontal number, (hitherto called the numerical indicator of the group) is added to twice the product, which was previously obtained by adding it to 7 ; thus : 3+7+10+3=23.

When these two harmonies are adopted as basis principles, we may construct a series of numerical tables, in which the cyphers hitherto called formal and numerical indicators in the original chain,—remain unchanged, while the central cyphers or new numerical indicators follow each other in a continuous arithmetical progression. For instance, in the next groups, the double arithmetical progression



on the circumference will be 4, 5, and 5, 6 ; while the corresponding central cyphers or new numerical indicators of the spheres will be 11, 12. Besides, as the addition of 7 to 4 or 5, will also produce 11 or 12, we obtain the same harmonies by this mode of calculation, as by considering the central cyphers in an arithmetical succession, without references to the constant quantity 7, which must be added to the number on the left of the central point of the group.

Proceding to the complementary numbers of each group, we construct them by doubling the central number, and adding the cypher on its left to the product. Thus the complementary numbers of the groups in which 11 and 12 are central, will be 26 and 29 respectively, because 11×2+4=26, and 12×2+5=29.

Finally, the lowest number of each group, will be the difference between the complementary number, and the sum of its upper and central numbers ; because it is one of the fundamental harmonies, that the complementary number should equal the sum of the upper, central, and lower cyphers of the group in question. Therefore, where the complementary numbers are 26 and 29, the lower numbers of these groups will be 10 and 11, because 26—5—11=10, and 29—6—12=11.

Hence it is evident that the relations between the central and lower numbers in the groups of the two chains, are *contraries*, as may be seen by placing them side by side. The relative position of the cyphers 10, 9, in the model group of the second chain, is the opposite of that of 9, 10; which is the order of the central and lower cyphers in one of the original groups; and this mode of *inversion* as regards *separate* numbers, corresponds with that which makes the *combined* number 23, the substitute for 32.

This mode of constructing a series of spherical groups, demonstrates the important fact, that the *addition* of 7 to the numerical indicator of any group in the original chain, corresponds with the *duplication* of that indicator, as regards the general harmony of any pair of groups in the two chains of numerical tables. It also follows that the chain of tables, now under consideration, has the same subordinate or dependent character in relation to the original chain, as that of the first form of *combined* circles, (or of the septuple figure), to the first simple form of a distinct enclosure of space, namely that of a blank undivided, and uncyphered circle.

SECTION IV.

On the harmonies between the two chains of numerical tables, and on a retrogressive *method of applying our ideas of fractional numbers to those of form, which lead us back to the first ideas of a* beginning.

WHEN we place the two chains in juxta-position, the harmonies which are made manifest, will furnish additional evidence in favour of their most intimate relationship.

The *model group* of the spherical or secondary chain, contains the cypher 10 as its central number, which equals 6+4, the central cyphers of the two opposite semicircles of the second and third original groups, in which 49 was the sum total of all their cyphers (see page 55). But as it has been already proved, that the second group in the original chain was the model of the succeeding links or groups in that series, which were constructed by arranging arithmetically-generated ideas of quantity in the same order, as its own mathematically-generated numbers were arranged,—we observe a new idea of progression in the contrast between the two chains, because the third, and not the second group in the secondary series, is the model.

The corresponding central cyphers of both the third groups are 6 and 10 respectively, thus demonstrating that those two cyphers hold the same relation to each other as the term of unity and 7. This may be shown in the parallelism, because it is possible to *retrograde* from the model group in the second chain having 10 at its centre, until we again attain the idea of 1 as a fraction in our arithmetical progression, or as the lowest demonstrable part of the integer.

But the corresponding *spacial* idea in this instance, will only be *a point* in space, and not a complete form like that of the circular representative of the integer. In both chains we lose the idea of a *quadrated* circle in the same relative position; and although the parallelism exhibits numbers in that group of the *secondary* series, which corresponds with the blank circle in the other series, there are only *four* cyphers in its parallel combination, and the deficiency is such, that they can only be arranged in the fractional form of a diameter of of the circle, combined with one of its radii resting upon it at right angles to itself. In this form, there will be a central number at the point of union, and that number will be 7. There will also be an upper and lower cypher, on either side of that at the centre: that *above* will be 1, and that *below* will be 6; while the *complementary* number will be 14. But there will be no *lateral* numerical indicator here; and this tallies with the fact, that that idea is represented in the corresponding circle of the first chain by the circumferential line of a blank undivided circle as the integral emblem of solitary unity. When referred to the circular form, this group can only image a semicircle.

Since, therefore, the blank circle in this case, is the *formal* representative of an integer,—the number 7 at the centre of the parallel figure, is the representation of a fraction of such an integer, expressed in an emblem of a divisible numerical quantity. The result brings us back to the first relation between *one* circle and the compact combination of *seven* equal circles, as connected formal ideas which generated all our notions of nnmber in the scheme.

This discovery coincides with another, namely, that 4, the *central* number of the sécond group in the *original* chain, has a two-fold power in this semi-circular figure ; we observe four cyphers in it, and their sum total is 28=1+7+6+14, or 7×4. But if we review our mode of synthesis in relation to the *second chain*, we find that the arrangement of the four first circular groups of numbers in the *original* chain, (so placed in relation to each other, that they represented 4 spheres,) was the new starting point ;—that this suggested the idea of 49 ;—that that sum was the total of three sets of cyphers variously distributed in those groups, as regarded their *diametrical* and *semicircumferential* lines ;—and that a new circle was thereby offered to the imagination, with cyphers so arranged that it became the model of our second chain.

If we continue the process of retrogression, we find that the *central* 7 in the *secondary* series must be preceded by 6 in the group above it, but that the upper cypher 1 disappears ; therefore we are reduced to three cyphers only in the next fractional group, where 6 at the centre of the new group will have 5 below it ; while 11 to the left, will be the complementary number attained by the only possible process in such a case (according to the conditions of the scheme,) that of adding 6 to 5. This and the remaining groups of the retrogressive series of numbers, will only suggest the forms of a rectangle (consisting of two straight lines,—one cypher being at the angle, and one at each extremity of the lines)—or of a quadrant of a circle.

When we arrive eventually at 1 as the central fractional indicator, it is in the same condition of solitude *numerically*, as the blank circle was *formally*, and ceases to be an emblem of comparison ; because 1 was the adjoining lower number in the group where the central number was 2. The retrogression of the arithmetical series, as regards the cypher *below* the centre, is at an end. On this account there can be no complementary cypher, because there can be no arithmetical process between numbers where only one exists; and the idea of a complementary number in our scheme is always that of a *product.*

But such a mode of analysis reduces our ideas of form to a *single* spacial point, which is *a first principle having an absolute character of non-entity so far as the occupation of space is concerned;* and it is impossible to push our enquiry farther, as we have attained the idea of *a beginning* both in regard to form and number. In the other chain we commence with the image of a blank circle, which is a complete form; but in this we end in such an absolute condition of *isolated solitude,* that we cannot image the idea of *limited distance,* or of a straight line, which was necessary as an element for the construction of the circle. (*c*)

(*c*) Unless we commenced our scheme with the postulate of the existence of *two* spacial points, it would have been impossible to construct any formal image; but as the abstract idea of *motion* is suggested by the *present* flowing into the *past,* we may apply it to the spacial quality of *locomotion as regards a single point.* It is true, that by *suddenly* applying *rest* (or the opposite of locomotion) to the *moving* point, we obtain the image of a limited straight line, and of one point at one of its ends, and of a second point at the other,—consequently of *two* points. But the difficulty in this case would be to discover *the origin* of an idea, which would suggest the mental production of *a limit,* because the analogy of the *continuously passing present* offers no such abstract notion of rest, or of a *cessation of motion.* In this respect, the *vis inertiæ of unceasing motion* is the only idea suggested.

When the *two points* are supposed to be *aboriginal* elements, and their relation of distance is to be formalised in the straight line, there is no such difficulty; because they may create the idea of *contrariety,* when they are *both* supposed to move in *opposite* directions; and the notion of a *limit* is constant *in the distance* between them; while the idea of continuousness is transferred from them to the circumference of a circle.

Having thus accounted for the origin of such ideas,—that of the *limit* is *transferred from the moving points to the circumference,* and from their *activity* to their *inactivity,* as soon as the object to be attained (namely, *the construction of the circumference*) *is completed.*

When the rotating line has performed half a revolution, that *object is attained.* Therefore it is more consistent with our whole scheme of deducing ideas from those previously in existence, to commence by supposing two points to be in motion as the *primary development of activity in relation to space,* than to determine *arbitrarily* upon some limit, which should be an impediment to the continued locomotion of

Reverting to the harmonies between the two chains, we find, that if we add 6 to the *formal* indicator of any group in the original chain, we obtain a product, which is the central number of the corresponding group in the secondary chain, 2+6=8, 3+6=9, 4+6=10, &c. This holds good as regards the fractional groups above adverted to; because the blank integral circle being considered as unity, the central number of the corresponding fractional group is 7: but in the preceding fractional groups, considered in a retrogressive method, the number which indicates its distance from the place of the *integral* unity must be subtracted from 7, until we attain the ultimate numerical fraction of 1, which coincides with the *informal* idea of a point in space, as has been just demonstrated,—and which also appears, when we subtract 6 from 7. (*d*)

CHAPTER VI.

ON THE IDEAS OF LOGARITHMS SUGGESTED BY COMPARING THE TWO CHAINS OF NUMERICAL CIRCLES.

SECTION I.

On the logarithmic relations between the numerical or formal indicators of each group in the original *chain, and the sum total of the cyphers in any corresponding group in the* secondary *chain.*

When we examine the relative positions of the cyphers in the first quadrated circle of the *original* chain, we find 2 at its upper pole as the formal indicator, and 1 on the left of the horizontal diameter, as its numerical indicator; while the sum total of all its cyphers, or 20, may be considered a pro-

a single point in space. This is still more evident, when we consider the continuous character of the passing moment, *which never can be at rest*, and which generates the abstract idea of a progression. The reader will comprehend this mode of reasoning more easily, when he turns back to the remarks on the possibility of extending the chain of circles in an *infinite series*. (See p. 51.)

(*d*) This retrogressive fractional

portional quantity holding logarithmic relations to them both. Therefore 2 and 1 both appear in this table in the double capacities of symbols of 20, and of fractional parts of 20, when they are reckoned as distinct indices of *tens*, as well as constituent *units* in the general combination. In the first capacity, they are strictly speaking logarithms.

The only numerical idea connected with the blank or undivided circle as an integer, is that which represents unity; and the same method of considering it as a logarithm, can only refer to fractional parts of such integer: but it does not take its place among them, in the same way as 2 and 1 do among the evident constituents of 20 in the succeeding circle.

Still if this *formal* idea of unity be expressed by 1, and that of duality be 2, as signs of a *formal* relation between the first and second circles in the chain, it is evident that the fractional parts of the undivided circle ought to hold the same *progressive* relation to the idea of 20, as 2 (in its capacity of *formal* indicator) does in the first quadrated circle. Therefore 10 becomes the *coincident* denominator of *fractional* division applicable in idea to the blank circle, although it contains no cyphers.

In the *secondary* chain we discover another *formal* system, in which the fractional division is denoted in numbers; and four cyphers, offering a total of 28, occupy a semicircular area which is parallel to the blank circle. Hence we assume, that the fractional proportion in this instance (if expressed in numbers,) will be as 10 to 28, while the semicircular form denotes, that in the general comparison, the blank circle of one chain only represents a semicircle in the other; accordding to this notion, a *complete* circle in the *secondary* chain gives 20 as the corresponding number of a single complete circle in the *original* chain, and 56 *as the perfect fractional quantity of a whole circle in its own chain.*

This is in accordance with the fact, that a *complete* circle

method is shown in the plate appended to the next chapter, which ought to be constantly before the reader during the perusal of that and the present chapters.

in the original chain, is the first quadrated circular area, and the first which contains a group of cyphers. But we find another order of logarithms in the secondary chain, in which 7 represents 28, because the first cyphered circle of the *original* chain (offering 20, as a sum total,) corresponds with the first complete circle in the *secondary* chain, where 7 is added to 28, and produces 35 instead of 56, which ought to have been the sum of its cyphers, had they appeared in full, as 20 does in the other. Hence the numerical indicator 2, in the first quadrated circle of the *original* chain, is a logarithm of 20 *in that chain, and of* 56 *in the other*, where 7 is the logarithm of 28. Therefore 2 is itself a symbol of the secondary logarithm 7 doubled.

When we advance in the parallelism, we find these two sets of logarithms increasing in the following ratio : 2, 14 ; 3, 21 ; 4, 28 ; 5, 35, &c. But the simple numbers represented by them advance in another ratio ; because 40 and 112, the totals, in the second pair of *complete* circles, develop the power of *duplication* in regard to 20 and 56 ; while 60 and 168 in the third pair, only denote an increase according to the laws of simple arithmetical progression, by the addition of 20 to 40, and of 56 to 112 ; or of *one* integer to *two*. Such a difference is at once explained, when it is referred to the formal idea of one circle being of necessity the repetition of another to which it may be added, while it is also the *second* in a continuous series. Hence the *third* circle is only the repetition of *the half* of the preceding compound form of two circles, while the second is *equal to the whole preceding one circle.* This notion is expressed by the numerical succession of 20, 40, 60, instead of 20, 40, 80, as regards the circles of the original chain.

When the idea is applied to the three companion circles in the secondary chain, it appears as $28+7$; $28+7\times2$; $28+7\times3$; which attributes a different logarithmic value to 7, when that number is multiplied by 2, from its meaning when it is not multiplied ; because 7 represents 28 only in the first complete group of the *secondary* chain ; but 7×2 represents 28×3 in the second circle of that chain, while

7×3 symbolises 28×5 in the third, and 7×4 is the symbol of 28×7 in the fourth. Hence, as regards the general harmony, the additional 7 is the representative of only half a circle in the *first* complete group of the secondary chain, but of a whole one in all the succeeding groups.

These remarks justify the assertion that the *numerical* indicator of each group in the *original* chain is the principal logarithm of the numbers contained in that group, or in its companion circle in the secondary chain, whether they be represented by simple cyphers or by subordinate logarithmic symbols : and as the blank circle of the *original* chain has no numerical indicator, we can only figure it by 0 as a sign of a formal unity ; although *it may be supposed* to be represented by 10 in that chain, and *it is really* represented by 28 in a parallel position in the secondary chain. (*b.*)

SECTION II.

On the subordinate logarithmic relations between cyphers in the same group, and in corresponding groups of the two chains.

WHEN we examine the two chains with the object of discovering subordinate logarithmic relations between cyphers

(*b*) Upon these *data* the following table of equivalent proportions may be constructed.

Principal logarithms, or numerical indicators.		First Chain.		Second Chain.
0	......	10	......	$28=7\times4$
1	......	20	......	$56=7\times4\times2$
2	......	40	......	$112=7\times4\times4$
3	......	60	......	$168=7\times4\times6$
4	......	80	......	$224=7\times4\times8$
5	......	100	......	$280=7\times4\times10$
6	......	120	......	$336=7\times4\times12$
7	......	140	......	$392=7\times4\times14$
8	......	160	......	$448=7\times4\times16$
9	......	180	......	$504=7\times4\times18$
10	......	200	......	$560=7\times4\times20$

It is worthy of remark that as 10 and 28 are the coefficients of 0, the above logarithmic series is entirely one of decimals, although the circles have been constructed without any reference to the numbers 5 or 10, as as leading arithmetical cyphers ;—the basis of the whole system being the mathematically-developed series, 2, 4, 7, 1, 6, 3, 4, 5, 2, 8.

of the same groups, or of the same pair of groups, we find that if 3, 6 on the horizontal diameter of the third cyphered circle of the *original* chain be considered as 36, that number is equal to the sum total of 3+10+23 on the horizontal diameter of the corresponding or model group *of the other* chain.

The same beautiful harmony is found in the succeeding pairs of cyphered circles, when 7, 14, 21, 28, or 7, 7×2, 7×3, 7×4, are successively used as compensating numbers in the groups of the secondary chain. 4, 8, or 48=4+11+26+7, and 5, 10, or 60=5+12+29+(7×2). This coincidence is constant, however the double series of cyphered circles may be extended; and it demonstrates, that when the numerical indicator of any *original* group is doubled, the product may be appended to it as a decimal fraction, provided it does not exceed 9, while the original cypher is the integral number; but that when it equals or goes beyond 10, (as happens when the original number exceeds 4,) the product may be, in part, added to the integer. Therefore 6, 12 may be treated as 72.

Thus in the second group, 2 is the logarithmic integer representing $\frac{20}{10}$, while 4 only represents $\frac{4}{10}$; the sum of the fractions being $\frac{24}{10}$. Likewise in the eighth group, 8 represents $\frac{80}{10}$, but 16 is only the logarithm of $\frac{16}{10}$, the fractional sum being $\frac{96}{10}$. In these cases the basis numbers are 2 and 8; but in the *secondary* chain we find 9 and 15 as central cyphers of the *corresponding groups*, which may be also referred to these basis numbers 2 and 8, when 7 is added to either of them.

Another logarithmic harmony between corresponding circles of the two chains, is of a more complicated character. We find that in the *original* chain the cyphers 3, 4, 5, 8, of the *second* group which are on its *right hand* semicircle, are equal to 20, and if we give its numerical indicator 2 on the other semicircle the value of 20, the two semicircles may be supposed to be formal components of one entire circle having the numerical value of 40. Therefore 2 has two values in this case. As a *general* logarithm of the circle it is the coefficient of 40; as a logarithmic *constituent* it only represents 20.

Supposing 2, 4, 8, to be each a logarithmic representative of 40, as a total of equal fractional parts, we find that the multipliers necessary will be 20, 10, 5, because $2\times20=4\times10=8\times5$; and this develops the general power of 5, as the lowest term of the increase, when it is applied to each cypher on the horizontal diameter of that circle. When the central 4 is multiplied by 2, and the complementary number 8 is multiplied by 4, we have the same result, $4\times2+(8\times4)=40$.

But the most obvious method, and that which is in the greatest consistency with our whole system, is to treat the complementary number 8 as a portion of the 40, or as $\frac{8}{40}$, and the central 4 as the equivalent of 12, or of $\frac{12}{40}$, in which case 2 will represent $\frac{20}{40}$. When it is remembered that 3, (apparent in $4\times3=12$,) is the *formal* indicator of the group, such a mode of giving a different value to 2 and 4, while 8 is unchanged, appears to be in harmony with the general scheme, and it may be adopted with modifications in every succeeding group of this chain.

In the other chain all the cyphers 3, 9, 8, 20, of the corresponding semicircle of the adjoining group, also equal 40; and as the remaining cypher in it, or 2, is treated as a logarithm of 40,—the two semicircles suggest the idea of 80 in the *secondary* chain, and the value of the complete circle there will be numerically the double of its counterpart. But if 2 itself, be reckoned as part of a sum total, we find a total of 42 in the second complete circle of the secondary chain. We have already seen that 42 in this instance may consist of two distinct sums, namely 28, and 7×2, in which 28 is a a simple number, while 7×2 is a logarithmic one of a peculiarly compound character, since it is itself capable of subdivision, one 7 representing 28, and the other 28×2, or 56. (*See* table in page 66). Yet this complication may be referred to its *formal* indicator, where there is a demonstration of *three* instead of *two*, as the term of the progression.

In its mixed character, 42 appears in this group as the representative of 56×2, or of four times 28; and as such it holds a fractional relation to 40, which has been developed in so many different modes in the adjoining circle.

Hence we have the following logarithmic proportions : 2 : 20 : 40 : 42 : 28 + (7 × 2) : 112.

As regards the next pair, in which 3 is the numerical indicator, there is as perfect a system of logarithmic equivalents. The *left-hand* semicircle of this group in the original chain contains the cyphers 4, 3, 7, 6, giving the same total of 20, as that found in the right-hand semicircle of the preceding group ; *there* its numerical indicator was 2 ; *here* it is 3 ; hence arise the two successive products of 40 and 60, by multiplication. But if 3 be considered as 30 in its capacity of a subordinate logarithm, and 6 be also treated as 30, the multipliers 10, 5, are again developed as they were in the preceding circle.

When we treat 18 as $\frac{18}{60}$, or as a simple fractional number, and 3 as $\frac{30}{60}$, the balance of $\frac{12}{60}$ is found by doubling the central 6 : and this method was adopted in the preceding group as the most consistent with the whole scheme. There however, the central number 4 is multiplied by 3, and the product is necessary as a compensating balance, in order to make up the fractional 40. But in the group now under consideration, the central cypher 8 offers a balance without being multipled. For the equivalent of 80 is found by making 4 in that group a logarithm of 40 or $\frac{40}{80}$, by treating its complementary number 32 as a simple fractional number, $\frac{32}{80}$, and by adding 8 in the same capacity, without multiplying it. Hence $\frac{40}{80} + \frac{8}{80} + \frac{32}{80} = \frac{80}{80}$.

In the fifth group, the central number disappears altogether as a compensating quantity; for its numerical indicator, 5, will be a logarithm of $\frac{50}{100}$, and its complementary number, 50, will represent a similar quantity, in full, and be the balance.

When we cease to look to the central number, for an element of compensation, we are beginning a new series of logarithmic proportions. In the sixth group of the original chain, its numerical indicator is still the general logarithm representing 120 ; but in its subordinate logarithmic capacity it must no longer be decupled. If the total 120 be accounted for by adding the complementary number to the co-efficient of 6, that co-efficient will be only 48, and it may be attained by the operation of 6×8 instead of 6×10, which has been hitherto the rule.

In the seventh group the balance 42 between 140 and its complementary number, 98, is attained by multiplying the numerical indicator by 6 : for $7 \times 6 = 42$. In the eighth group, 32, the balance between 160 and 128, equals 8×4. In the ninth, $180 - 162 = 18 = 9 \times 2$. And in the tenth, the complementary number alone, or 200, is the fractional equivalent of that circle.

Hence we discover a new system of elimination which disposes of the logarithmic properties of the central number, and of that cypher itself in the series of the *first five groups;* while the numerical indicator always represents *tens.* But in *the next five groups*, the numerical indicator has a regularly diminishing logarithmic value, and at last disappears in its compensating capacity in the tenth group, as the central number did in the fifth.

Thus it is evident that there are subordinate as well as general logarithmic values attached to the numerical indicators of the groups, and indeed that every cypher on the horizontal diameter of a circle has many logarithmic values, all of which are demonstrative of the complete harmony of the whole scheme.

SECTION III.

On the logarithmic relations between the incomplete *groups of cyphers, which are produced by a* retrogressive *calculation of the elements of the secondary chain.*

WHEN we direct our attention to the incomplete fractional ideas, which precede the first complete circle of the *secondary* chain, it will be found that this series consists of *six* groups of cyphers, and of *one* solitary cypher which is the *numerical* indicator of a single spacial point. Therefore, in this chain it would be incorrect to represent unity by 0, as is done in the other; its representative is 1; and this number is succeeded by 2, 3, 4, 5, 6, 7, in an arithmetical progression, all which terms of the progression are the respective logarithms of the sums total of the cyphers in each of such incomplete groups. This has been already proved in regard to 7 when considered as a logarithm of 28, or of the total of the four cyphers of that semicircular category, which corresponds with the *formal* unity, or blank circle of the original chain.

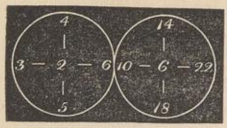
As the spacial point is the solitary and absolute beginning of the secondary chain, we are precluded from terming it a group or category; but the totals of the next *five* fractional groups may be considered in their formal capacities as counterparts of each other, because their constituents in each case are three cyphers. On the other hand, the seventh or last incomplete group in the series which is parallel to the blank circle in the other chain, consists of four cyphers, and on that account it must be treated in its formal relations as a distinct figure.

Now it will be found that if the *numerical* demonstrators of each of these five groups be arranged in a complete circle, and the separate totals of the groups be placed in relative positions in another circle,—two new circular tables will be constructed, one of which is a logarithmic representation of the other.

Let 2, 3, 4, 5, 6 be so placed that the cypher 2, is central to the others, and that 4 and 5 are at the two ends of a polar diameter of a circle, while 3 and 6, are in similar positions as regards the equatorial diameter.

Next with respect to the totals of the cyphers in each of these five fractional groups,—if $6=2+1+3$ of the second be central in the other circle, $10=3+2+5$ should be the left-hand equatorial cypher represented in the logarithmic circle by 3; $14=4+3+7$ should be the upper polar number having 4 as its logarithm; $18=5+4+9$ should be the lower polar cypher having 5 as its logarithm; and $22=6+5+11$ should be the right-hand equatorial number represented in the logarithmic circle by 6.

On comparing the two circular tables thus arranged, it will

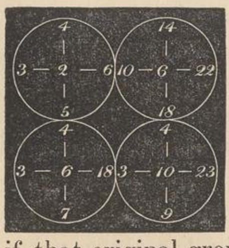


be seen that their respective totals are to each other as 20 to 70. But when 70 is referred to 14, as a divisor, the product will be 5, or the number of incomplete groups employed, each of which may be treated in a formal capacity as a quadrant of a circle ; four of such quadrants will be numerically equal to 14×4, or to 56,—the fractional value of a complete circle in the secondary chain.

Hence, as one of the cyphers is 14 at the upper pole, the lower semicircle is the formal equivalent of the remainder, or of 56 ; and therefore, it corresponds with a complete circle of the same chain. But as we have seen that throughout that series, 7 has a logarithmic value of 28,—we are justified in maintaining, that the semicircle in which 14 is located here, is like its opposite, the representative of a complete circle : supposing it be represented by a logarithm, while the other semicircle contains 56, expressed in full.

Therefore we arrive at the conclusion, that the new table, composed of the combined fractional values of the 5 incomplete groups, is the compound or mixed numerical representative of two complete circles in the secondary chain, or of $\frac{112}{56}$.

Again, if we examine the parallelism between the chains, we observe that in the first pair of complete circles, we have only 20 in one of these groups ; while 28 added to the logarithmic 7 (also 28), or 56, is the value of the other: this proves that the new circle, having a value of 112, must be the substitute for a subsequent group of the *secondary* chain. Now, if we consider the two new groups as the substitutes for the *second* pair of quadrated circles, it will be found that we have as regular a succession, when the *new logarithmic* group represents the *original second* group, as if that original group remained there ; and this is of more importance because *the model group of the secondary chain is a part of the figure.*



The total of the cyphers in the new group is 70, while that of the *model* or succeeding group is only 49. But we have seen that $56+(7\times2)=70$, while $28+(7\times3)=49$; and this mode of dividing 70 and 49 produces the same co-efficient 112, supposing 7 in both cases to represent 28. Hence both these groups are numerically equal to two complete groups of the secondary chain, each of which has the value of 56 ; and we conclude that all the cyphers of the incomplete groups which make up the new circle, become the equivalents of the *model* group of the secondary chain.

Then as regards the new logarithmic group, its right-hand semicircle contains the cyphers 4, 2, 5, 6, which equal 17, the complementary cypher of the first complete group in the secondary chain; but when this new circle of logarithms is substituted for the second group in the original chain, as is the case here, we find the semicircular value of 17, preceding the cypher 18, of the third original group, while 22 precedes 23 in the other chain, in the same position ; and the common difference between these two sets of cyphers, 17 and 22, or 18 and 23, is 5, which is the quantity of incomplete groups or quadrants of a circle, employed to constitute the new circle having a value of 70.

But there is a relation between the logarithms 3, 2, 6, and the geometrical series 3, 6, 18, which indicates a decided contrariety ; because the logarithms 3, 2, 6, when multiplied into each other, produce 36, which is denoted in 3, 6 ; while on the other hand, $3+2+6=11$, which 11 is the half of 22 ; so that these three cyphers in the logarithmic table are connected with the third original group by multiplication, and with the new compound group of fractions (which is the substitute for the companion circle of that third group), by addition.

Not only, therefore, do we discover logarithmic relations between the incomplete groups, which are obtained by considering the secondary chain as a retrogressive system, leading us back to the idea of an *informal* spacial unity; but we find that the fractions thus obtained are capable of synthesis, and of constituting new proportional relations in regard to *form*, since they suggest *the same formal* idea (that of a complete circle), whether they be represented in full, as 6, 10, 14, 18, 22, or by a logarithmic method, when such cyphers are symbolised by 2, 3, 4, 5, 6. (*c*)

(*c*) In concluding this first portion of the treatise, which contains the elementary rules for attaining the idea of a general development of simple forms, and of coincident numbers,—the attention of the reader is called to the important fact, that not only are such ideas of *special terms of quantity* suggested, in a peculiar series, by our meditation upon the possibility of imagining those of form without reference to the material world,—but that these very numbers themselves, when they are connected with such formal images, give birth to ideas of new formal and numerical harmonies.

Numbers denoted by cyphers, having abstract *spacial* relations to each other in the circular groups, hold a sort of analogy to ordinary alphabetical characters; and the whole system typifies our notion of a written language. But neither our practical method of describing the sounds of a language by written alphabetical signs, nor the more barbarous mode of representing visible objects by hieroglyphics, can be said to resemble this mathematical plan of framing point-like signs of quantity in circular tables; because there is no resemblance between the emblems, or between the modes of their application, in the two cases. Every letter or hieroglyphical sign of a language must have its own peculiar *formal* churacter; but the idea of any number exists in the mind independently of all those notions of form, which may have suggested it in the first instance, as well as of that of a cypher in which it may be denoted. It is true, that in human association, the idea of a quantity must be communicated (either audibly or in writing) by some special sign through an organ of sensation; but the *abstract idea* of a quantity, when referred to a locality in space (a point in one of our circles), may have a particular value determined by that relation, and be always present to the imagination as a specific number *in consequence of its position*, although its *spacial* representative is a mere point.

The basis-notion of *logarithmic* representation is a due appreciation of this fact. The same formal image has a different value according to its locality, in a perfectly harmonious system of formal relations, although the representative cyphers are themselves exactly alike.

BOOK II.

ON THE HARMONY DEVELOPED BY APPLYING A MATHEMATICALLY-GENERATED SYSTEM OF NUMBERS TO THE ABSTRACT SERIES OF FORMAL IMAGES, BY WHICH THOSE NUMBERS WERE ORIGINALLY SUGGESTED.

BOOK II.

INTRODUCTION.

As our simplest *formal* ideas of combination are those of a plane figure composed of *seven* equal circles,—of a quadrangular solid, composed of *four* spheres,—and of a pentagonal six-sided solid, composed of five spheres,—we shall be proceeding systematically, when we apply the first seven, four, or five cyphered groups of the original chain of circles to these combinations.

Enough has been already advanced in the first book, to prove that the chain of cyphered groups develops one complete scheme of *numerical* and *formal* harmonies. But so many collateral ideas of proportion, and even of dynamical laws, are suggested, when the above compound figures are constructed by combining these groups,—that it was deemed expedient to examine them in detail in this portion of the work, before the attention of the reader was directed to various methods of considering the groups of numbers, as *models* which have their influence throughout the material world, in relation to chemistry, physics, astronomy, and botanical or zoological physiology.

Should the reader be disposed to pass over the contents of this second book, and proceed at once to the practical application of the abstract scheme, he may spare himself much tedious meditation upon the arithmetical and formal properties of the cyphered circles which are constructed on principles laid down in preceding chapters. But the treatise would be incomplete without an attempt to demonstrate that the primary progression of the numbers 2, 4, 7, 1, 6, 3, 4, 5, 2, 8, is as much supported by the combination of the cyphered groups, when they are arranged in *compact* figures, —as it is, when they succeed each other longitudinally as links of a continuous chain of circles.

The general rule for combining them is,—that the *horizontal* line of each cyphered circle should represent the direction of a *centripetal* force, while the other or polar diameter in the same circle is the type of a continuous current; because each *horizontal* diameter exhibits a *complete geometrical* process (as regards the cyphers inscribed on it), while the cyphers on the original or polar diameter are only a portion of a general arithmetical series which is continued in a succession of circles, and which may be extended infinitely as the chain itself may be.

Hence it follows, that in every compact combination of superficial circles, the complementary number, or that expressing the highest quantity in the group, ought to be the nearest to the central point of the general figure; and although the *central cypher* is converted into an *axis number*, when the superficial circle is treated as the representative of a sphere (see note (*b*) p. 57) while the four other cyphers of the group in question are all supposed to be inscribed on the equatorial circumferential line of the sphere,—still the highest of those four numbers, or the complementary cypher of the sphere, must be so placed that in the general figure it is the cypher nearest the central point of the aggregate.

It may be necessary to premise, that the application of the different groups of the chain of numbers to separate atoms in the physical world, according to this method, is not advanced as a model idea which has been literally or *practically* made manifest in nature; but as an exemplification of the perfect harmony of the abstract numerical scheme itself, even when it is so applied *in theory*. Every *ultimate* atom in each distinct molecule of a simple chemical substance, may be supposed to bear a perfect resemblance to every other *ultimate* constituent of the same molecule.

BOOK II.

CHAP. I.

ON THE COMBINATION OF THE SUCCESSIVE GROUPS OF THE ORIGINAL CHAIN OF CIRCLES, IN THE SEPTUPLE FIGURE WHICH FIRST SUGGESTED THE IDEA OF THE NUMBER *SEVEN*.

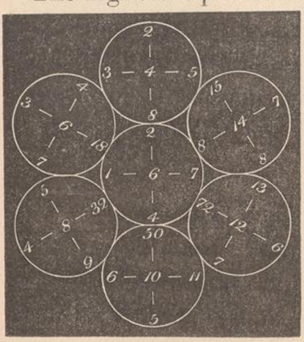
SECTION I.

On the general harmony of the septuple combination of cyphered circles, in relation to its diameter and its highest complementary number.

LET us construct a septuple figure by making the first numerical group of our original chain, the central circle,—and by arranging the second, third, fourth, fifth, sixth, and seventh round it, in the order in which they appear in the chain itself.

The first or central circle of the general figure should be so arranged as regards the others, that its polar diameter should be on the same line as the equatorial diameter of the second and fifth groups; while all the other groups should be connected with each other and with the first, in such a way that the direction of their equatorial diameters should be *towards the centre* of the figure, while their polar diameters should describe the outline of a hexagon, and typify a continuous current in one direction, returning into itself between the upper polar point of the *second* group and the lower pole of the *seventh*.

The highest equatorial numbers in all the groups, except the first, will be expressed by the cypher nearest the circumference of the central circle, and become portions of radii in the general figure; but there will be only one unbroken diameter running through the whole figure, and that will be made up of the *horizontal diameter of the second* group, —of the *polar diameter of the first*



or central group,—and of the *horizontal or equatorial diameter of the fifth group.*

This line contains the cyphers 2, 4, 8; 2, 6, 4; 50, 10, 5; expressing a sum total of 91. When 7, which is the number of circles in the figure, or the highest number in the central circle, is added to 91, the product 98 is exactly equal to the number expressed by the highest number in the figure, the complementary number of the seventh group, 91+7=98. We shall have occasion to examine this crowning coincidence in the combinations of six other series of the septuple arrangement; but before we apply other groups to the same septuple relation of circles, let us fix upon a common test of coincidence between each group of the external ring of circles and that of the internal circle in the combination already before us.

As the *last* equatorial number in each group is invariably *the highest*, and has a fixed relation to the circumference of the central circle in this figure,—the constant test of coincidence may be sought for in that relation. After having examined it in the six cases contingent on the septuple combination, we can proceed to the analysis of successive coincidences between the great diameter and the seventh circle, in septuple combinations, when we construct similar figures by bringing groups together which express higher ideas of quantity than those found in the numbers of the *first seven* tables of the chain. These two methods of displaying the unexpected harmony of such combinations, prove that the marvellous qualities of the original sevenfold combinations are co-extensive with every attempt to connect the idea of that formal arrangement of circles with arithmetically-produced numbers, however high such numbers may be.

SECTION II.

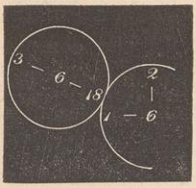
On the special coincidences between the complementary number of each group in the septuple combination, and the nearest cyphers in the central group.

THE general coincidence between the first and second groups, or numerical circles, is so complete, that we want no special relations of coincidence to convince us of their intimate connexion; still we find that 8, the highest number of the second table, at its point of contact with the first, corresponds with the total of the two *nearest* numbers in the first, 2+6=8. This is the coincidence which we require.

As regards the third group:

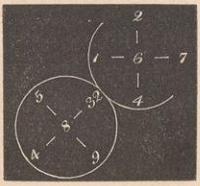
18 is at the point of union between the first and third numerical circles; it is also midway between 2 and 1, and opposite 6 in the central circle of the figure. Thus a new combination is formed in which the complementary number of the third group equals the double of the sum of the three cyphers to which it is nearest. 18=1+2+6×2.

Again, 18 is midway between 3+6 and 1+2+6, as a *medial sum total*, and it has the same position in that capacity as 6 itself holds in the central circle between 2 and 4. This idea of a medial sum total is one of the earliest suggestions of numbers in the first group. 2=6−4.



As regards the fourth group:

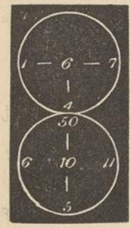
32, its complementary number, is between 1 and 4 in the central circle, but we find the last coincidence reversed in this instance: if we add together the other three cyphers on the circumference of the fourth group, and those on the equatorial diameter of the central group, we find 32 as a sum total. (5+4+9)+(1+6+7) =32.



Again, if we add the sum of the cyphers, nearest 32 in the central circle (1+6+4=11), to the sum total of the *similar* *quadrant* of the *fourth* table, which are 4+9+8=21, we find the general total to be 32. This coincidence is perfectly harmonious, because 32 is a *medial sum total* between these *similar* portions of the *first* and *fourth* circular groups of numbers, notwithstanding the unpromising appearance of 11 and 21, which are the respective totals of the cyphers so situated.

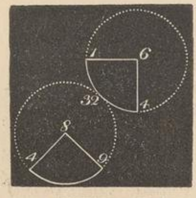
As regards the fifth group.

The point of union between the circles is at the junction of the *polar diameter of one* with the *equatorial diameter of the other.* The complementary number, 50, is a medial sum total between all the other numbers of its own group and all except the upper polar numbers of the first or central group. Thus—

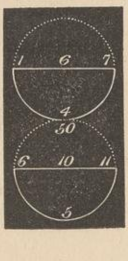


$$\left.\begin{array}{r}6+10+11+5=32\\1+6+7+4=18\end{array}\right\}50$$

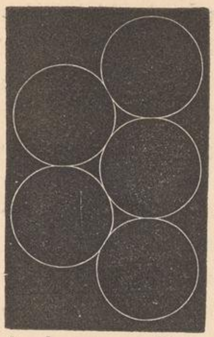
Here we find the cyphers representing 32 and 18 respectively, on the boundary lines of two separate semicircular forms, as the last were on those of two quadrants. A new harmony is thereby developed, and a further proof of the truth of our theory is made manifest, in form as well as in number : because the two corresponding *quadrants* of the fourth and first tables are together equal to 32, the complementary number of that fourth circular table, and *these two quadrants are together equal to a semicircle*, which is represented as such by 32.



In this instance we find 6+10+11+5= 32 on the lower semicircle of the *fifth table ;* and when it is added to the sum of those cyphers on the corresponding semicircle of the *central* circular table, we perceive that both sums together equal the complementary number of the fifth group, which is 50, while the two *formal* semicircles are equal in superficial capacity to a complete circle.



Now when we recollect that our ideas of *five*, as a mathematically suggested quantity, originated in the figure imaged by the central and four contiguous circles, *out of the*



seven, which is precisely that formal quantity and shape which we have as yet examined,—the development of the new suggestion, that the last or *fifth* numerical table should bring us back to the two semicircles or entire circle, (while the last but one, *or fourth*, is connected with the form of two quadrants or an entire semicircle) is in perfect accordance with the fact, that the numbers *four* and *five* have peculiar qualities in combination. Here indeed *four* again appears in connexion with the *quadrated* division of the circle, as it did at first; but it now connects itself with *two quadrants* or a *semicircle.* But in the next groups we find, that *five*—which was a younger numerical idea than that of the *fractional* four, since it is the penultimate number suggested in the combination of seven distinct circles, or the value of five distinct spheres,—now connects itself with the form of *unity*, or the whole circle.

The *great diameter* of the sevenfold combination is completely developed in the figure composed of *five* of its contiguous circles; and as only half of each circular area is formally engaged in the production of 32+18=50, the diameter is *virtually* the limit of the combination. This phenomenon is the more interesting, as it conveys the idea, that although in its *formal* quality no *individual circle, through which the diameter passes, is capable of division*—yet in its *numerical* character each of those circles may be bisected, and the special value of its semicircle may be taken into account in the general problem, *as a formal quality.* Hence we arrive at the following conclusion, which, *formally*, would be unattainable; namely, that *the half of the figure composed of seven circles* has a most intimate relation to the original circular type of unity, *or one circle.*

It follows, also, that if *five* be the influential number in reference to this incontestable truth, involving *one half* of the septuple combination of circles, *ten* will be its double, and will bear a numerical relation to the whole combination, which consists of *seven* equal portions, each of which is incapable of division: nor is it the least harmonious result of the whole problem, that 50, or 5×10, the indicator of the half multiplied into the whole, should be the complementary number of the two semicircles which are formally equally to the whole circle.

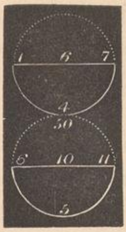
The result in a purely *formal* sense is, that the whole figure of seven circles has a relation to *two* circles, because half that figure has a relation to *one* circle; and this tallies with the doctrine that we may refer all our ideas of form to the motion of *two points*, at a fixed distance from each other, or of the imaginary straight line. It also reminds us of the blank circle at the head of our original chain being the parallel of a semicircle only, in the secondary chain. (See p. 66.)

But the *two* circles are themselves suggested by the one septuple combination of circles, in the long and complicated process of mathematical and arithmetical thought, in which we have been involved.

As if every idea in connexion with this most marvellous display of abstract fitness was but part of the scheme, we find the idea of *two* in combination, (which we must remember was first suggested by *the remaining two circles*, when we supposed a subordinate figure of *five* out of *seven* circles—or by the *two additions* of a sphere to either side of triangular arrangement of three spheres)—we find this idea of *two*, as a numerator of distinct things, in the number of circles which is to make up the whole combination, and to *represent*, as it were, *a second arithmetical idea of five.*

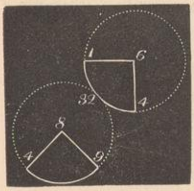
It appears in the same formal position as it did at first, but its characters are more complicated than they were then, because it returns back to those *formal associations* of the mind out of which it first arose.

Arithmetically it has two characters here; for it doubles another number, while it is added to it. In one character it is productive of 10,—in the other of seven; *while in its formal* capacity, it exhibits two circles added to five others, but having the same effect as if the total of seven circles were only five.

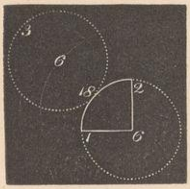


In taking leave of the harmony between the fifth and central groups of the figure, we may observe a progression which is complete in the fifth, in relation to the original circular form.

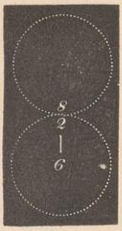
The joint *numbers* of the corresponding semicircles in the central and fifth tables of the combination, indicate the *circular form*. 18 + 32=50.



The joint numbers of corresponding quadrants in the central and *fourth* tables of the combination indicate the *semicircular form*; in this and the preceding instance the *complementary number* expresses the total of the numbers so employed. 11 + 21=32.



The numbers of the quadrant in the central circle, which are nearest the *third* table, and the radius at the equatorial diameter of that table,—indicate the quadrant only, and the influence of the semi-diameter—or the two radii of the circle and the arc of the quadrant, which are represented by the complementary number 18=9 + 9.



The numbers of the single radius of the central circle correspond with the complementary number in the second which is nearest it. 6 + 2=8.

Thus we find four sets of numbers, indicating form.

1. That between the first and second tables indicates the *radius* of the circle.

2. That between the first and third tables indicates the *quadrant* depending on the radius.

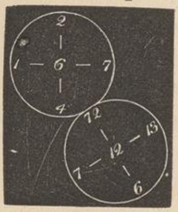
3. That between the first and fourth tables indicates the *semicircle*.

4. That between the first and fifth tables indicates the *complete circle*.

It is only in the union between the fourth or fifth tables and the first, that we find the type of a combination of *two* formal enclosures of space ; in the third table we see that its *radius* is added to the quadrant of the first, which is indicative of *that transition* or *mean* between superficial and solid qualities which has been already noticed.

As regards the sixth group.

Its complementary number 72 represents a sum total composed of all the other numbers of its own table, and the duplicates of those of the adjoining quadrant in the central circle,

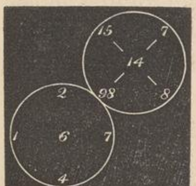


$$\begin{array}{ll}\text{Thus} & 7+6+13+12=38 \\ \text{and} & 6+4+7\times2=34\end{array}\Big\}\,72$$

Formally these numbers indicate *one* semicircle, and *two* quadrants, which are still only the respective parts of one entire circle.

This result, which is unexpected, seems to intimate, that after the first *formal* idea of the circle is *regenerated* by an arithmetical process, we cannot produce other circles in the same *fractional* form ; and this is proved by the obvious constitution of the complementary number in the seventh circular table, and the idea of a second circle to which it gives rise.

As regards the seventh group.



Its complementary number is equal to the total of the numbers on the nearest semicircle of the central circle *when doubled*, and of the other numbers on its *own circumference also doubled.*

$$\begin{array}{l}\text{Central group...}2+6+4+7\times2=38 \\ \text{Seventh group......}8+7+15\times2=60\end{array}\Big\}\,98$$

The numerical result is, that in regard to 98, we find two tabularly divided circles represented in these numbers ; those belonging to the central group describe the duplication of its diameter as well as the circumference of its nearest semicircle ; while those of the seventh group only indicate the form of a *double semicircumference:* and the formal result in the second case, is the reconstruction of only one complete *undivided* circle.

In this combination we have the values of two circles, but they are *formally* different: the numbers taken from the seventh group *do not include the central number*, although, when doubled, they suggest the duplication of the arc of a semicircle. Those, on the contrary, in the central group, include the central number, and suggest the formal idea of both diameters. As it has been already shown, that the formal idea of the centre is not generated, until the diameter is bisected, it seems a legitimate inference that, where 98 represents the total of two sets of numbers,—one set including a central cypher, the other rejecting it,—that which does not contain such a type of the central point, should typify an undivided circular enclosure of space, or the first imaginable figure, which has its place at the head of the chain of numerical tables, although it is the unnumbered emblem of unity.

Hence we discover that the first and seventh tables of numbers in their relations as parts of the septuple combination, not only suggest the *formal* ideas of two distinct circles, but they lead us back to the original form of the blank superficies which was generated by the ideal motion of the straight line, and has been the basis of all our speculations about number or quantity.

A new idea of *two* offers itself here, in the two first numbers of that progression, which is indicated at the upper pole of every circle in the chain except the first; and the perfection of the system is still more marvellous, when it is recollected, that this idea of two is precisely that which the first number in it notifies—namely that the circle in the centre of the figure is the second in the chain, but that the blank unnumbered circle is *that outline* of form which is first generated by our intelligence in the ideal world.

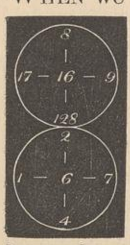
Two here is not indicative of two similar things, like two points in space or two similar circles; but of two objects which are *generically* alike, but *specifically* unlike, while they are still the first and second in a series. But the admirable perfection of this return into the idea of two, appears in the fact of its being the complement of all our previous reasonings mathematical and arithmetical.

Thus we finish our examination of the *cyphers* of the seven circles, by the resuscitation both of the single blank circle and the first model of the divided circle, in the contemplation of which we attained all our mathematical ideas of form and number. But it may be inferred that the blank circle represents the original *combination* of seven similar circles, which was itself the primary idea of *formal* combination. The *latest formal* idea thus resuscitated, is that which *first* presented itself to our contemplation, when we imagined the *opposite* ideal motion of two points, connected by the lineal representation of the fixed distance between them,—to have described the circumference of a circle.

SECTION III.

On the coincidences between the successive septuple series, in which the first group of the chain is always central.

When we replace the *second* numerical table by the *eighth*, we find its complementary number, 128, equal to twice the other numbers in that group, added to twice the *circumferential* numbers of the first or central group.



$$\left.\begin{array}{l}\text{Eighth group} \ldots\ldots 9+8+17+16\times2=100 \\ \text{First group} \ \ldots\ldots\ldots\ldots 2+1+4+7\times2=28\end{array}\right\} 128$$

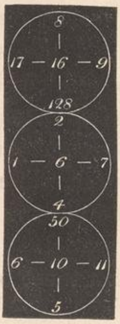
In this instance the new formal idea suggested by such an apportionment of the 128 differs from that which is regenerated in the analysis of the complementary number of the seventh group, 98, so far as the progression is concerned.

There, the blank undivided circle was typified by the circumferential numbers of the seventh group; and the divided or quadrated and numbered circle was represented by the duplication of cyphers selected from those of the first group in the centre of the figure. Here, the first group in the same general position, is the type of *two blank circles*, because its circumferential numbers must be doubled in order to represent 28 ; while the *eighth group* represents *one quadrated and numbered circle*, because the numbers on its upper semicircle must be doubled, and 100 will represent the two semicircles.

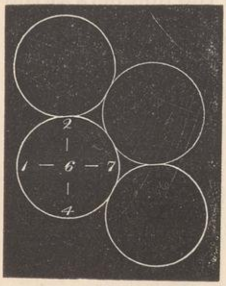
This appearance of 128, as a complementary number, justifies our method of placing the first cyphered circle of the chain in the centre of the septuple figure, when a *new or second series* of external tables is about to be ranged round it: and we may infer, that the first circle must be repeated as a central constituent in every septuple series, however high the values of the other groups in it, may be.

Another harmony of the eighth numerical circle, when it replaces the second in the septuple combination, proves that *it is in its place there, instead of being central to the new series.*

We have already seen that 50, the complementary number of



the fifth group, suggested the formal idea of the perfect circle made up of two semicircles (see pages 83, 84.) In this eighth circle we find all its numbers (except the complementary number), equalling 50, and presenting to the mind an idea of an entire circle, in relation to the fifth. But the complementary number of the eighth circle is 128, being the sum of $6+5+11+10$ (the other numbers of the fifth circle,) multiplied by *four*, which multiplier is the nearest cypher in the central circle. $6+5+11+10 \times 4 = 128$.

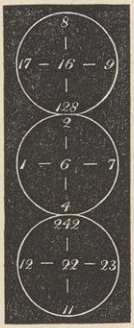


Moreover there are four circles in the problem, if we suppose the central group engaged in it ; and the respective position of those circles is that of the *subordinate* fourfold *figure* in the *general septuple* union of *seven* circles, which first suggested the idea of *four*, as indicative of so many units in combination.

Thus 128, in reference to *the lower semicircle* at the other end of the *great* diameter (or $6+5+11+10$), gives a new formal idea of *four* times that capacity, or *four semicircles;* precisely as 50 in reference to that semicircle, and the nearest half of the central circle, gave the *formal idea* of two semicircles, or one perfect circle.

Hence the *eighth* group represents the *formal double* of the fifth, and it is in its proper position, when it replaces the second at the upper end of the great diameter instead of the first group which is central to the whole figure.

But supposing we replace the *fifth* group by the *eleventh*,



(which would be its substitute in the second series, in accordance with this mode of arrangement), we find that its complementary number 242 is equal to $6+5+11+10\times6+50$, or to the separate quantities, 1st of 32 (the total of numbers which represented the formal semicircle), multiplied by six, and therefore equalling *three* perfect circles, and 2ndly of 50 (which represented the semicircle in question, and the nearest semicircle of the central group), thus adding a fourth perfect circle to the other three. Hence 242, *the complementary number* of the *eleventh*, represents *four complete* circles, while 128 in the *eighth* represents *two such forms*,—and 50 in the fifth represents *one only*, as has been satisfactorily proved.

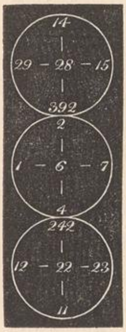
Another test of the peculiar relations between these opposite groups, is found in the following harmony.

$128+8=136$, represents the sum total of the numbers at the upper and lower pole of the eighth group; but $12+11+23+22=68$, represents those on the lower semicircle of the eleventh group: 136 is the double of 68.

Therefore we attain a new idea of capacity and relation, in which the two polar numbers of one group, 136, indicating the foregone conclusion of the bisection of a circle, are equal to the double of the sum total of cyphers on the lower semicircle of the opposite group, $68\times2=136$.

Hence we find that when the *eleventh* circle is referred to the *fifth*, it offers the formal idea of *four bisected circles*, but when it is referred to the eighth, or its opposite, we are brought back to the regenerated form of *only one such* circle.

When we follow up the method (already adopted in this section) of comparing the *complementary* cypher of the *first* group in the third, fourth, fifth, sixth, and seventh *series* of septuple combinations, or of the 14th, 20th, 26th, 32nd, and 38th cyphered circles of the original chain,—we shall find each such complementary number holding *a regular progressive relation to the total of the other cyphers in its own circle*, but leaving a *remainder*, which may always be *referred to the first cyphered circle of the chain*, which circle ought therefore to be central in every series.



For instance, 392, the complementary number of the *fourteenth* group, with which the *third* series commences, is equal to *four times* the total of *the other cyphers* in that group, and to a remainder of 48.

The successive development of this harmony is as follows, and the reason why 8 appears in all the remainders, is self-evident.

	Complementary number of the commencing group.		Other cyphers of the commencing group.						Remainder
1 Series......	8	=	3+ 2+ 5+ 4	—	6	=	1	+	7
2 do.........	128	=	9+ 8+17+16	×	2	=	100	+	28
3 do.........	392	=	15+14+29+28	×	4	=	344	+	48
4 do.........	800	=	21+20+41+40	×	6	=	732	+	68
5 do.........	1352	=	27+26+53+52	×	8	=	1264	+	88
6 do.........	2048	=	33+32+65+64	×	10	=	1940	+	108
7 do.........	2888	=	39+38+77+76	×	12	=	2760	+	128

Now when we apply the remainders to the first circle of the original chain, we find the following *formal* results.

1. In the first series there is the value of the complementary number 7 of the first group, which was also the numerical indicator of the fractional semicircle, having a sum total of 28, in the secondary chain. (See table in page 66).

2. In the second series, the remainder 28 either indicates *two blank circles*, because all the circumferential numbers of the original first group being equal to 14, 28 refers to the duplication of that formal idea, (see first calculation in this

section, page 88),—or *one blank circle*, when considered according to the mode of constructing parallel chains, as is shown in the table, page 66. But in reference to the problem immediately before us, it is the compound form of two undivided but concentric circles, which may thus be treated as the constituents of the central portion of the double septuple figure. This idea of two equal circles in that *concentric* condition is one of our earliest conceptions, in regard to the generation both of a second distinct circle, and of an ellipse. (See section VI of the Introduction to the first Book).

3. In the successive developments of the remainders (after having passed the *idea of duplication*, as regards one septuple series placed upon another) we find the numerical symbol of an important change: 48, 68, 88, are each capable of being divided into two distinct quantities, namely, the original 28, and an additional quantity of 20, 40, or 60, which is obtained as 20, 20×2, or 20×3. In relation to the successive septuple series, this demonstrates that we attain a *limit* as soon as we have reached the *thirteenth* group of the original chain; and that we are thenceforward to consider the central group of a series, as the representative of a divided circle instead of that blank circular enclosure of space, which is suggested by the harmonies in the first and second septuple series.

Thus 48 equals $14\times2+20$, or two sets of the four circumferential numbers of the first group, and one entire sum of all its five cyphers; while 68 appears to testify two blank, and two quadrated circles for the same reason. In the *seventh series* the number 128 may be applied in the same way to two blank circles, and to *five* quadrated circles, each of which five has the numerical value of the first circle of the group.

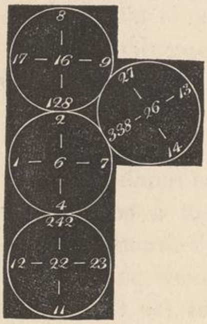
When this abstract idea is brought to bear upon the atomic theory, it suggests the existence of a law which limits *simple ultimate combination* to forms having no more than two layers of atoms in their primary conditions,—as will be shown in the Book, where this practical application of such doctrines to chemical laws, is enlarged upon.

The main object, however, in introducing this notice of the numbers at one end of the great diameter of the *septuple* figure in different series, is to establish the principle in our system of combination, which insists on the *first* group being repeated in every series; and the important corollary,—that beginning from the second group, we proceed to construct a *sextuple* ring, or succession of *rings*, *out of circles taken* from the chain *by sixes*; so that although the form is always that of seven circles, the central group is unchanged, when the others are changed. We shall find, when this idea is materialised, that the central circle represents something distinct from the realisation of the other six: we have already seen that a complete series of *seven* groups of numbers *including the first*, generates the *new formal idea* of a completely bisected or quadrated circle, as well as a blank circumferential enclosure of space: this notion becomes more palpable as we advance in our enquiry, and prepares us for the hypothesis, that any material combination, which appears to consist of *fourteen* atoms in this form, either contains a centre of two atoms which have different qualities from the other twelve, or (although occupying the space geometrically belonging to fourteen) *consists only of twelve*, because the central portion capable of containing two such atoms, is void.

As it seems most probable, that such is the primitive form or basis of form, of the *ultimate nitrogen* molecule, in the chemical world,—it is of importance to notice this abstract inference about the qualities of the *first group* developed in *every* septuple combination of the cyphered circles of the chain, as soon as it is suggested by our ideal creation of a second seriês or layer of circles or cyphers, which may be placed above or below the first superficial series. It is evident that at least two layers must be in contact to satisfy the conditions of atomic *solidity*, in regard to such a form.

The examination of the relations between the seventh circle of a series and its great diameter, also affords evidence in support of the *constant presence of the first group, as central to every series.* We have already seen that 91, the sum total of the numbers on the great diameter of the first series, (when added to the number of circles in the combination, which is 7), equals the complementary number of the seventh group, which is 98. In this instance 7 is the index of unity; but in the next series, 1 is the index of that series itself, as it is of the *second* place of cyphers in logarithms of numbers.

Now we find 439 to be the sum total of the numbers on



the great diameter of the second septuple series, (the first group retaining its position there), while the sum total of all the numbers in the seventh circle of that series—the thirteenth group—is 418= (14+13+27+26+338). If to that sum we add the total of all the numbers in the first group and the index of the series, the balance is perfectly adjusted; 418+ 20+1=439.

To follow up this examination in other series requires a more complicated process, the complication increasing with the progression of the series, until we arrive at the eighth series, when the balance is adjusted by a comparatively simple operation; but throughout the progression this adjustment is complete, when some number or numbers of the first group or central circle are taken into the account (if it be necessary to search beyond the seventh circle for a suitable cypher), and the indicator of the series is either added or subtracted.

When we calculate the relations of the great diameter and seventh circle of the *eighth series*, we find a simplicity in the balance, which announces a new category, and tallies with the fact that we have passed the square of the original seven, or the quantity of 49 circles. We borrow nothing from the central circle in this case, although it is still the first group of the chain of numbered circles, but we stand in need of the indicator of the series, which is the original number *seven*; it is used here as it was in the balance between the great diameter and seventh circle of the first series.

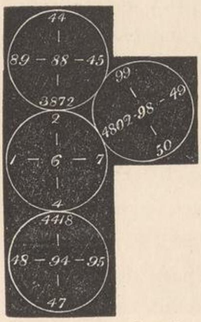
In the eighth series:

The great diameter equals 8575, *and is balanced* as follows :

1. The complementary number of the seventh circle or forty-ninth group, *when doubled*, is . . . $4802 \times 2 = 9604$
2. The other numbers of the same group quadrupled (to be subtracted) give a negative sum total of . . . . . . $296 \times 4 = 1184$

		8420(*a*)
3. The upper polar number . . .	= 50	
4. The central number	= 98	
5. The indicator of the series . .	= 7	
	155	155
		8575

Here we observe that the *central* number of the seventh circle in the *seventh* series is 98, the identical cypher of the *complementary number* of *that circle* in the *first* series.



We also find 50 at its upper pole, which was the complementary number of the *fifth* circle in the *first* series, where it was the regenerator of a new *formal* idea of one perfect quadrated circle, and the type of a half series of seven circles.

The number 7 is the original term of the basis quantity in the septuple combination.

Many beautiful developments of harmony crowd upon the mind in meditating on these facts. The great diameters of the *first* and of the *eighth* series, the central number of the *fiftieth* circle or forty-ninth group, and the complementary number of the *seventh* group, are respectively related to each other, in a manner which proves incontestably, that from first to last, our theory of the original development of numerical ideas is abstract truth; and that the number *seven*, divided into its portions of *six* and *one*, is the basis of a continued

(*a*) When we compare 4802 and 8420 in this problem, we discover an *inversion* of 48 and 02 which is very remarkable, considering the complexity of the operation: 48 becomes 84, and 02 becomes 20. It suggests a peculiar sort of fitness of every part of the system to every other part, hitherto unnoticed. A more extraordinary development of this harmony produced by *inversion* is demonstrated in a subsequent chapter.

ideal action, in which form begets numbers, and these numbers produce new forms, which again give rise to new ideas of number; the alternation going on to such an extent as to weary our powers of calculation. Still *seven* is the great numerical key of the mighty system: but next to seven in importance is *five;* and *ten* its duplicate *follows five*, while *fourteen connects* the ideas of *ten* and *seven*, by the *intervention of two* and *four*.

The whole of this progression, is the condensed summary of our calculations. In the *first* series, or circle, we find the basis of that which is represented in the *eighth series* or *single* circle. 7 is the highest number in the first circle. 14×7 is the highest number of the first series. 98×49, or 14×7×7×7, is the highest number in the eighth series: yet its produce 4802 has a most harmonious *formal* connexion with 5×10 and 14×7, when the first idea of *formal* combination which suggested the numerical idea of 7, is made the *governing principle* of all subsequent calculation, and of our interpretation of the laws of natural arithmetic.

SECTION IV.

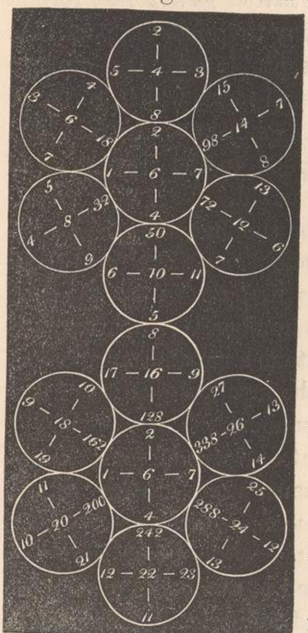
On the harmony produced by combining the first and second septuple series of the original chain, in such a mode as to offer the appearance of a single septuple series.

Our idea of atomic or abstract solidity as regards the combination of spheres, is not found in a single superficial septuple figure. Two layers at least are necessary to formalise the idea of a solid, and new relations of harmony are created by their juxtaposition.

Let us construct two figures, arranging the first seven groups in one, and the next six, from the eighth to the thirteenth (both inclusive), round the repetition of the first of the chain in the other.

Let us then suppose these two superficial figures laid upon each other, in such a way that the opposite poles of their great diameters should be in contact, so that the *fifth* group in one figure might be *under or upon the eighth* group, which is the second circle of the other.

This arrangement will reverse the direction of the polar current, and occasion its representation in the *sequence of numbers* to indicate *opposite* directions in the two contiguous figures. To use a familiar term, the one figure will be *hinged* on to the other, by the connexion between the *fifth* or *lowest* circle of one and the *eighth* or *highest* circle of the other, and these two leaves so connected must be supposed to be closed upon each other, so as to offer the image of only one septuple figure.



The calculation of the cyphers of any two superincumbent circles, will give a sum total indicative of harmony, and corroborative of the coincidences of the single superficial figure. If the *four first* pairs in the consolidated ring be compared, it will be found *that each pair offers a common sum total of* 82.

The other two pairs have another common sum total of 118, and this tallies with the discovery that the fifth circle in relation to the first (see p. 82), completes one formal idea of a new circle, while the remaining two, *or the sixth and seventh*, belong to another special division of the figure.

For instance, if we designate the groups by their numerical relation to the *original* chain.

The 2d contains 3+ 4+ 5+ 2=14 } 82
The 11th .... 12+11+23+22=68 }

The 3rd, 4+ 3+ 7+ 6=20 } 82
The 10th, 11+10+21+20=62 }

118 { 44= 8+ 7+15+14 The 7th
{ 74=13+12+25+24 The12th

The 4th, 5+ 4+ 9+ 8=26 } 82
The 9th, 10+ 9+19+18=56 }

118 { 38= 7+ 6+13+12 The 6th
{ 80=14+13+27+26 The13th

The 5th contains 6+5+11+10=32 } 82
The 8th .... 9+8+17+16=50 }

The complementary number is never taken into the account.

Now this numerical consolidation gives a new numerical *common value* for those four pairs of circles which end *formally* in the position occupied by the fifth group, and it has been already found that that group so situated gave a new formal idea of a complete circle. We may therefore suppose that by bringing the two series of the septuple combination into contact, we have attained a compound form, which, so far *as its moiety is concerned*, is not only an emblem of abstract harmony, but is capable of being applied to the realisation of material solidity in the substantial world.

This surmise is strengthened by the fact, that if we arrange the *first four circles in the solid triangular form* (supposing them to be spheres), or the *first five in the six-sided solid*, we shall find half 82, or the number 41, on every one of their sides; a coincidence so astonishing and unexpected, that it almost induces a belief in the mystical qualities attributed by the ancients to certain numbers.

However, the harmony of the *whole figure* of fourteen circles is not at first satisfactory, because there are two sets of circles in pairs; the one with the common number of 82, the other with that of 118. The attempt does not supply us with the idea of a general compound of numbered circles put together in the septuple form, and numerically balanced in *all* its pairs, which is the *desideratum*, more especially since we have found the idea partially, in one part of the combination. The solid combination of fourteen spheres numbered as the thirteen circles are, would be numerically *heavier* on one side than the other.

It will, nevertheless, be found, that when seven such *formal* combinations are the constituents of a more complicated figure, the requisite equilibrium may be obtained, supposing all the *cyphered* groups of its central portion be the copies of the *first numbered circle* in the original chain.

CHAPTER II.

ON THE HARMONY DEVELOPED BY COMBINING FORTY-NINE PAIRS OF CIRCLES IN A FIGURE, WHICH RESEMBLES AS NEARLY AS POSSIBLE THE FORM OF THE ORIGINAL SEPTUPLE COMBINATION.

SECTION I.

On the construction of a figure containing ninety-eight circles:—and on the disappearance of the uneven numerical results, which were the consequence of treating each double septuple series composed of the first thirteen groups of the chain, as a distinct and independent figure.

The constant prevalence of the number *seven*, and the power of the septuple combination of circular forms in solving and analysing those complicated ideas of proportion, which hold a coincident relation to our ideas of number and form,—make us reluctant to give up the hope of finding a harmony in that figure, which may correspond with our notion of *an ideal even balance in weight* throughout the arrangement.

That this is not to be obtained by placing a third septuple series or layer upon the other two, is self-evident: but if we suppose fourteen spheres disposed in two connected septuple layers, as the *central portion* of a general figure, composed of *seven* such combinations of fourteen,—to hold the same relation to the other six combinations, as the single central circle does to the other six *single* circles which surrounded it in the *simple* septuple combination of circles,—we attain the idea of a form which does exhibit the required condition of an even balance in the relations between the centre and circumference, as well as between the different distinct portions of that circumference.

In arranging the *external* hexagons (for the tangential lines of each subordinate combination will cut each other in such a way as to suggest the hexagonal form), we should place the tangential lines common to their sixth and seventh circles, in connexion with the sides of the internal hexagon. This will make the outside pairs of the whole figure have a common numerical value of 82, while the central pair of each *external* hexagon will represent the common number of 40, because each such separate portion of the figure will consist of two copies of the first circle of the chain, which is valued at 20.

The *internal* hexagon will therefore be bordered by a hexagonal chain of twelve pairs, each having 118 as a common number.

In order to remove the unevenness of the *central* hexagon, we must apply the principle already established about the distinct nature of the central circle in the simple figure, to the centre of this general combination; each of the *outer circles of the central hexagon* must represent the *first* cyphered group of the chain, or the second circle of the *formal* progression; but the two central circles themselves must be the counterparts of the first *blank* idea of circumferential form, which is at the head of the chain.

As two repetitions of the first group give a total of 40,—the numerical value of the space occupied in the general figure by the central or *internal* double hexagon, thus modified, will be exactly equal to that of the *six central pairs of the external hexagons*, because it contains only six such pairs, each representing the same common sum of 40. (*a*)

(*a*) A plate representing this complicated figure, will be found at the end of this chapter, and the reader is recommended to have it open before him during his perusal of the following calculations.

SECTION II.

On the general harmony made manifest, when the cyphers of the great compound figure of 98 circles are valued in different categories.

1st. If in our attempt to discover the general harmony of this figure, we proceed from the circumference to the centre, we find, that each external pair of the entire combination, contains the numerical value of 82; and as there are twenty-four such pairs of spheres or circles, they give a total of 1968=82×24.

There are twelve pairs of circles or spheres next within those on the outside, each of which has the numerical value of 118. Therefore the total of their cyphers is 1416=118×12.

There are six pairs in the internal hexagon, and the same quantity in the external hexagons (the central pair in each), which have a common numerical value of 40. Therefore the total value of these twelve pairs is 480=40×12.

Finally, the number of circles or spheres in the whole combination which represent the groups in the chain *other than the first*, are 72, because there are twelve pairs representing the first group, and two circles representing the blank circle—in all 26; which when added to the 72, will account for 98, the entire number of circles in the combination.

Now, adding together,

1. The value of the 12 pairs of 118	=	1416
2. That of the 12 pairs of 40	=	480
3. The number of circles which represent other groups of numbers than the first group . . .		72
We find a total number of		1968

This is the general value of the twenty-four external pairs, which bound the figure, each of which is valued at 82. For 82×24=1968.

Secondly. If we examine the harmony in the opposite direction of a line from the centre to the circumference of the figure,—

1. Its centre is the representation of undivided unity, or the first circle of the chain.

2. The other six pairs of that hexagon, representing the second formal or first numerical group of the chain, complete the first hexagonal arrangement.

3. The second general hexagonal arrangement outside the first, consists entirely of the groups, which compose the sixth and seventh pairs of the subordinate septuple combinations.

4. The third or last general hexagonal enclosure, consists of thirty-six circles, or eighteen pairs of such circles, and it exhibits the counterpart of the original polar current in the subordinate septuple figure, because it contains the only general diameter of each of those component parts of the general combination now under consideration; we have already calculated the relations of these lines, separately, as regards each distinct septuple combination, and called them the great diameters. In this instance, they are the counterparts of the polar diameters of single circles, and they are connected with each other, as the *polar diameters* of the single circles were, in the simple septuple combination when they typified a circulating current. (See p. 79.)

5. Each double septuple combination, considered in its relation to the general figure, has *two salient or projecting* pairs of spheres or circles, which are beyond the third great hexagon of the whole system, when it is treated as one, and not as seven different figures. Therefore these twelve *projecting* pairs appear to belong to the subordinate septuple combinations, and their cyphers are balancing quantities as regards the separate sums total of each such subordinate arrangements.

The heaviest side of each separate hexagon is nearest the common centre; but in the general hexagon, the highest numbers are on the great hexagonal series which is equidistant from the central blank circles on one side, and from those two projecting pairs on the other.

Hence it follows that,

Viewing the whole combination as a series of concentric hexagons, we find :

1. A central pair without numbers	. . . . .	0
2. First hexagonal line nearest centre, 40×6	. =	240
3. Second ditto, 118×12	. . . . =	1416
4. Third ditto, (82×12)+(40×6)	. . . . . =	1224
5. The projecting pairs, 82×12	. . . . =	984
Numerical value of the general figure		3864

This summary exhibits the following surprising harmony, 240×6=1440—24=1416. The result is remarkable, when it is remembered, that *six* is the number of external subordinate combinations, each of which consists of 14 circles. The total quantity of circles in this instance is 84: but if we subtract from this quantity 12, the number of the *central* circles in the *six* external combinations in question, we obtain 72, the quantity of their circles which are *not* the repetitions of the *first* circle in the chain. Still, if we suppose each of these 72 circles to be the repetition of that group, having a numerical value of 20, we find that 72×20=1440.

It is, indeed, altogether out of our ordinary ideas of numerical harmony, that such a result should be obtained by such a mode of proceeding: but the harmony is not confined to this mode of analysis. 118×2 is the sum total of all the cyphers (always excepting the complementary number) in the 6th, 7th, 12th, and 13th groups or numbered circles of the chain, transposed or reversed in such a way, that the 6th and 13th, and 7th and 12th form pairs. When the value of of these pairs is multiplied by 12, we have a product of 1416. Yet, by a wholly different process based on an hypothesis which is an incorrect assumption, viz. that every cyphered circle in the general figure is like the others,—we find the number 1440. When we deduct from it 24, which specifies the exact quantity of circles which have that number, 40, as the type of their pairs,—the product is the identical 1416.

Again, we find another harmony of the same character in another process. 240 is the number connected with the pairs in the central hexagon which have the common value of

40 attached to each pair : but when that is multiplied by 8 (the number of circles in each external hexagon, which, when paired, have the joint numerical value of 82 per pair), the result is 1920, to which let us add 48, the number of the *cyphered* circles *on one side* of the whole figure. But 48 single circles are the constituents of 24 pairs; and if 82 be *multiplied* by 24, the produce is the same as that obtained by the *addition* of 1920 and 48, namely, 1968. Here we find the same sort of coincidence as that in the last sum, which affords a proof of the connexion between the abstract truths developed by the general figure.

Now, if we add to 1968, all the values of the circles in the central hexagon, or 240 (which was the basis of that sum 1968), it is obvious that we obtain a sum total equivalent to that offered by the *five* pairs of all the external hexagons, because the central pair of each of the six subordinate combinations is equal to one of the pairs of the central hexagon. This addition, however, gives a total of 2208.

When from this total we deduct 1416, which is the total of the numerical values of all *the other* cyphered pairs (the remaining two pairs in each external hexagon), we find a remainder of 792: for, 2208—1416=792, while 2208+1416= 3624, which 3624 is the numerical value of all the pairs in the six *external* hexagons. Therefore, 792 *represents the difference between the value of all the pairs, having a common value of* 118, *and those outside them.*

Now, we have already found that 72 is the balancing number between all the pairs of numbered circles which have a common value of 82, on one side, and all the other numbered circles in this combination on the other, while it indicates the quantity of all such numbered circles as do not represent the first group of the chain. Treating this number, 72, as a divisor, and the 792 (which is the difference between the values of the pairs that are numbered 118, and of the others) as a dividend, we attain 11, as a product.

But 11=5+6; and 5 is the number of the pairs of circles, in each *external* hexagon,—which have not a common value of 118; while 6 is that of the hexagons, in which these pairs are found. The basis of this last operation was the 2208, the joint numerical value of the five pairs in the six hexagons.

The whole calculation appears in the following process :—

$20 \times 12 \times 8 + 48 + (20 \times 12) - (118 \times 12) = 792$, and $\frac{72}{792} = 11 = 5 + 6$. The numbers used in this operation have reference to distinct categories or quantities of circles in the general figure, determined by their relative positions, as well as to cyphers in such circles. Yet, notwithstanding their diversified involutions, the result is the development of a truth, both as regards the formal and arithmetical conditions of certain cyphered groups in it.

The complexity of this operation, and the perfect harmony which it develops, confirm the idea that the general figure is as complete a formalised representation of *abstract* arithmetical *truth*, as any single circular group in the chain is.

Thirdly,—as regards the great diameters of the series. It is obvious that the great diameter of a *first* septuple series, must differ from that of the *second* on which it is superposed : for instance, that of the first series, as we have already seen, is 91, but that of the second series is 439. If we reject the complementary numbers in both cases, we must deduct 8 and 50 from 91, which leaves 33 : and for the same reason 439—128—242=69. Multiplying 33 and 69 by 6, (the number of subordinate combinations in the whole circumferential part of the figure), we obtain the two products of 198, and 414.

The difference between these two numbers is 216 ; and if that number be divided by 6, we find 36, the number of pairs, which, when added to 72 (the number of single circles in the whole figure which do not represent the blank circle, or the first circular group of the chain), makes up the total of the circles in the general combination of 98.

Should the joint sum of 33 and 69, (viz. 102) be the amount for which a harmony is wanted, we find it in the following mode of computing the great diameter by pairs, instead of by separate series.

2+4 of the second group, added to 22+11 of the eleventh group, produces 39.

5+10 in the fifth group, added to 16+8 of the eighth group, gives also 39.

In the above method of obtaining 39, the *complementary numbers* of the groups in question are not taken into the account; but this rejection of the *third* cypher does not apply to the central circle in a septuple series. Therefore we combine 2+6+4, and we double the product, because the first group is common to both layers. Hence we have 24.

If we add these three sums together (39+39+24=102), we attain the harmonious result, which was desired: this sum, 102, tallies with the number of spheres or circles, *which are cyphered* in the whole combination,—when that number, 96, is added to the number which indicates the six hexagons, or six formal repetitions of the first hexagons, 96+6=102.

Fourthly. As regards the relation of the one *internal* and the six *external* hexagons.

Each circumferential, or numbered circle of the internal hexagon, exhibits a total of 12 on its polar diameter, (2+6+4=12) and of 14 on its equatorial diameter, (1+6+7=14.

As there are twelve such circles or spheres in this part of the general figure, we find that by multiplying 12 or 14 by half the number of circles, or by that of the pairs in question, we attain the new quantities of 72 and 84.

The result is in perfect harmony with our foregone discoveries: 72 represents the exclusive quantity of *cyphered* circles in the figure, which are not representatives of the first group, while 84 indicates that of *all* the circles, which belong to the *external* hexagons: therefore 72 and 84 are the *general* polar and equatorial numbers of the internal pairs, while they denote both the whole quantity of the external pairs, and of that portion of those pairs which does not resemble the pairs in the *internal* hexagon.

Fifthly. As regards the *character* of the *internal* hexagon.

It may at first appear an arbitrary proceeding to assume, that all its *six* outer pairs should be the representatives of the first group doubled ; but the assumption is justified by the analogy between this larger combination and the original septuple series, in all that concerns that group ;—and the new mode of arrangement is suggested by the numerical relations of the whole system of seven hexagons, of which this central one is a portion.

The *first group* in the septuple series is emblematic of a relation *common to all the other six:* when the formal series is doubled, this first group is doubled, while all the others are replaced by higher numerical circles in the second series.

As this larger combination of seven hexagons is the copy of the single hexagon or double septuple series, the central hexagon is the enlarged representation of the central circle or pair of circles, and it should have a general relation to all the other hexagons, as that circle has to the other circles in the septuple arrangement. This would not occur, if it were composed as the others are ; because *their* special *irregularity of balance* is necessary to the general regularity of the figure in which they are combined : but the central hexagon must be evenly balanced *within itself*, or it would not harmonise with them, *because the portions of each external hexagon which is in contact with it, are exactly alike.*

The surprising harmony between the different quadrants of the central circle and the different contiguous groups in the single septupal series, depends upon their *corresponding irregularities ;* but there must be a corresponding regularity, where *one* member of a *binary* compound is *regular:* therefore the *outer* pairs of the *internal* hexagon must be numerically *alike*, because the *adjoining* pairs of the *external* hexagons are all alike.

For the same reason, the *central pair* of the whole figure cannot represent the first group or its duplicate. It is in contact with regularity, because although that first group is individually irregular, its six-fold repetition produces a regular figure, and its constituent circles are in contact with the central circle ; 7 being the only cypher in them, which appears at the point of contact.

Therefore, as there is no general idea of a single group of cyphers in our chain of cyphered circles, which is a type of numerical regularity; we are obliged to recur to the first idea of the undivided and *unnumbered* circle for individual uniformity, and to suppose the central pair of this comprehensive figure to be the representation of two blank circles or spheres, because regularity cannot be otherwise attained when the contiguous member of the compound (or the six circumferential circles) is itself regular.

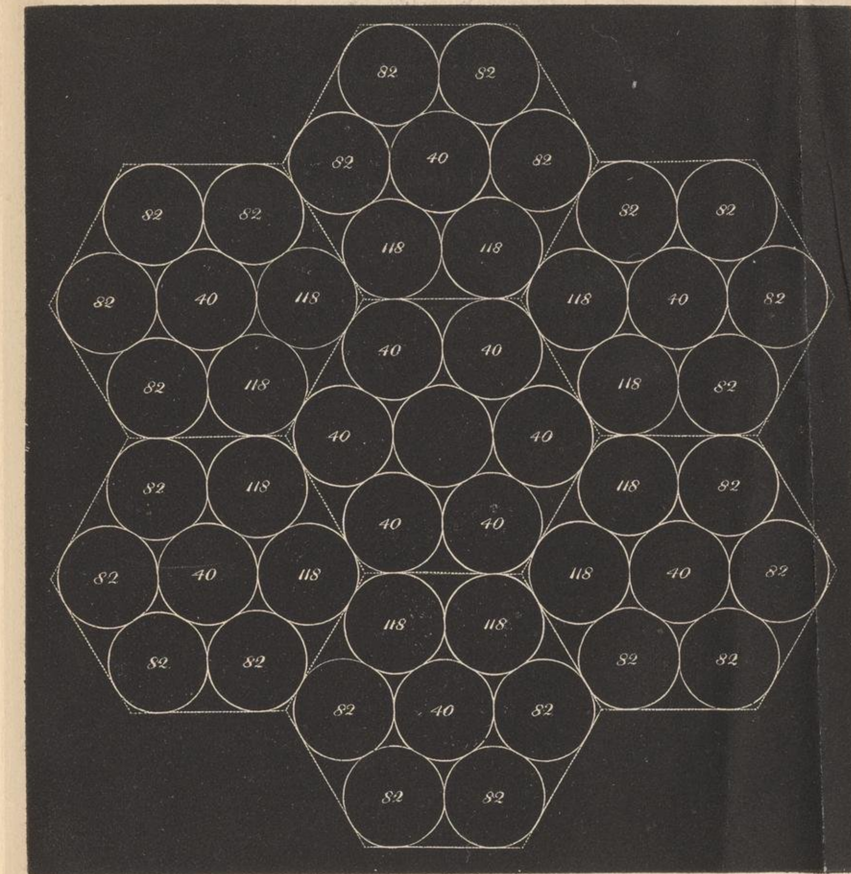
Our numerical relations when considered in reference to the whole figure, are equally indicative of the propriety of constituting the central hexagon, in this manner.

The appearance of two common numbers (82 being common to four pairs, and 118 to two pairs, of the double septuple combination) suggested the probability of their each forming a category of numerical values, which would be balanced in the arrangement of all the cyphers of the general figure.

It was found, that 1968 was the value of all the external pairs, or all those pairs which had a separate and special value of 82; the balance was made up by adding 240 and 72 to the values of the other pairs belonging to the external hexagons; and as 72 was the quantity of all the groups in the figure, which did not represent the first group of the chain, that indicator of quantity was at once accounted for. There only remained 240.

To divide 240 by 14, the number of distinct circles in the central hexagon, would have given a product which is less than the value of any group in the chain: but to divide 240 by 12 (the quantity of circumferential circles in that hexagon), seems most reasonable on other accounts, while the product in that case is 20, the precise value of the first *numbered* circle in the chain. Thus the balance was complete, when we supposed each of the external circles of the central hexagon, *to represent that group;* and the two central circles to be the copies of the first *blank* circle, or the copy of the prime idea of a perfectly uniform enclosure,—as opposed to the infinitely extended medium of absolute space.

Plate III. *To face page* 108.



CHAPTER III.

ON THE RESULTS ATTAINED BY APPLYING THE CYPHERED TABLES OF THE ORIGINAL CHAIN OF NUMERICAL CIRCLES, TO OUR FORMAL IDEAS OF SOLID FIGURES, WHICH ARE COMPOSED OF SPHERES.

SECTION I.

On the most obvious method of applying the plane circular *tables of cyphers to* spherical surfaces.

It has been already remarked, that the combination of three spheres suggests the idea of a *transition* between the superficial and solid conditions of spherical aggregation; but we have not yet supposed the three first *numerical* circles to be brought into contact, as the constituents of a distinct figure *independently of the septuple combination;* nor have we constructed the figures of the quadruple and quintuple solid aggregates of spheres (which suggested the repetition of the series, 3, 4, 5, 2), by applying the four and five first circles of the chain to such a purpose. Before this is done, it may be necessary to determine upon the most obvious method of making these numerical tables represent spheres (*a*).

It is evident, that when circular cyphered tables are combined in particular modes, and in accordance with the rule constantly observed about the *closest* contiguity being the most appropriate,—they may be considered in the double capacity of representatives of complete forms which are as incapable of scission, in regard to their integral formal qualities, as the chemical atom is,—but which are nevertheless amenable to our ideas of analysis, with respect to those points on their surfaces on which specific terms of fractional

(*a*) In a note appended to a preceding chapter (see page 57) this conversion has been merely alluded to, but not explained in detail.

quantities, or numerical cyphers, may be inscribed. Therefore the *circumferential line* of every cyphered circle in the chain, is identically the counterpart of the first circular enclosure of space, whose division suggested our primary ideas of proportional quantities in a regular succession, when we deduced such ideas of number in the first instance, from *formal* images.

The generation of a sphere in our system of progressive development, depends upon the previous generation of the circle ; and as this advancing process involved a principle of contrariety, when we transferred the ideal element of motion from the diameter to the circumference of a circle, and supposed that diameter to be an inert axis of rotation, instead of being a straight line rotating on its own central point,—we proceed systematically in applying some analogous rule *involving a contrariety*, to the conversion of the *superficial* circular table of cyphers into one, which will be applicable to the *projecting surface of a sphere.*

Such a notion is formalised, when we imagine the circular table to be the equatorial *plane* of a sphere : and the central number of the circle will then be on the axis of the sphere. But if the position of this cypher be assumed to be that of a pole of the sphere, instead of its central point, we must either determine that it is common to the whole axis,—or that it is divided into two equal parts, as regards the two poles ; *or that it is doubled, and therefore apparent at both the poles.* The last of these suppositions leads to an inference, that the sphere should be *bisected at its equator as two hemispheres,* and that the other four cyphers must also be doubled : this conclusion appears to be supported by the relations between the blank circle at the head of the original chain, and the next circle,—the one having an uncyphered fractional value of 10,—the other of 20 : and it is further borne out by the appearance of 40 in the second cyphered circle, which is the double of 20.

Hence, each circular group may be considered as the representative of only one hemisphere ; the spherical counterpart of the first circle ought therefore to have the four cyphers, 4, 2, 8, 14, on its equator, instead of 2, 1, 4, 7 (*b*), while it would still have 6 as a single number at each of its poles. Such a method, however, would not attribute any *central* number to the sphere, as all its cyphers would be upon its surface.

Hence, as regards our calculations, we may treat the numbers of the circular tablés, either as the logarithmic halves of the corresponding spherical numbers (the mode adopted in this chapter), or we may double them. Either method will be available, when we search for the harmonies in the spherical combinations about to be examined.

Strictly speaking, the terms of *polar* and *equatorial* cyphers hitherto used in relation to the circular groups, cease to be applicable to these cyphers, when they are considered in relation to the spheres; because *both diameters* of the circular groups, *are on the equatorial planes of the spheres*, while the central cypher in the circle is one of the polar cyphers in the spheres; the other polar cypher being its repetition. This change has already been a postulate in the *secondary* chain of circles, which was derived from the original chain, and compared with it in the preceding book of the treatise (*c*).

SECTION II.

On the application of the first four circular tables of numbers in the original chain to the idea of a quadripartite solid combination of spheres.

As the *triple* combination of circles, which is repeated so frequently in the simple septuple combination (see page 9),

(*b*) This idea is formalised in the practical application of our abstract theory to the doctrine of chemical equivalents, if 14 be the constant equivalent of nitrogen, or the number of the ultimate constituents in each of its distinct particles. It will be shown in a subsequent part of this work, that the practical application of the number 7 to the basis of the nitrogen molecule, is apparent as 14.

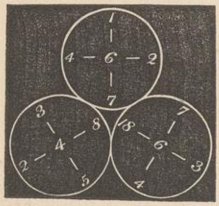
(*c*) Perhaps the best terms of distinction between the diameters, as regards the sphere, will be those of "*arithmetical*" and "*geometrical*," because the cyphers on one diameter exhibit an arithmetical series in the original chain, while the progression on the other diameter is geometrical. But the terms of polar and equatorial are still used in this chapter, because the circles which are applied to spherical combination, are those of the original chain.

exhibits the most compact mode of bringing circles into contact,—that form has been already supposed to be the primitive type of solidity in relation to the conjunction of distinct formal images.

It is evident, that when the septuple figure is composed of seven circular groups of numbers, having the first group at its centre, its circle must be a constituent of all the six triple subordinate combinations of the general aggregate. But the only subordinate arrangement, in which the complementary numbers of three groups in this figure are evenly placed, as regards its general centre, is that which is composed of the first, sixth, and seventh groups. (See figure in page 79.)

In order to obtain the same *formal* relations of the complementary cyphers of the first, second, and third groups in the figure, we may merely imagine the central group to make the third part of a revolution on its axis. This will bring round its complementary number to the position required: the equatorial diameters of the circles in question will then converge to a common central point, in the triangular void between them. (*d*)

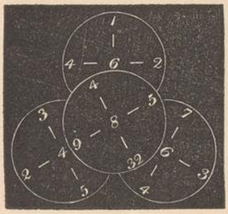
The juxtaposition thus attained is productive of some coincidences in regard to their cyphers, which would not appear



if the circles remained in their original relative positions in the septuple combination. The numbers 7 and 9 become the constantly suggested products of contiguous cyphers here, as may be seen when we examine the harmonies of this new figure; but an attempt to demonstrate these facts will divert our attention from the object immediately before us,—namely, the examination of the numerical properties of the quadruple and quintuple solids, when their constituents are the first four or first five circular groups of the original chain.

(*d*) This is the first instance of the application of the idea of rotation to *an entire circle:* hitherto, we have only imagined the rotation of a diameter of a circle upon its central point, or that of a circumference upon the polar diameter in regard to the generation of the spherical form. The rotation of a complete cyphered group is therefore an advance in the general theory.

When this triple combination of the first, second, and third groups is considered the basis of the new quadruple figure, and the interstice between them is covered by the *fourth* group (so placed that its central cypher 8 is on the central point of the triangular void between their arcs), we obtain a perspective or fore-shortened view of the spherical solid thus constructed. The relations of the diameters of this fourth circle to the other circles, will be found to depend upon the direction of the diameters of the second circle. A line drawn from the numerical denomination of that group will pass over the point of contact of the first and third in the original basis combination of three groups; and if we determine that the formal denominator of the fourth group shall be upon



that line, it follows that its polar diameter (denoted numerically by 5, 8, 9) will be on the same line as the horizontal diameter of the second group; this may be seen in the adjoining figure, which has been already referred to as the basis idea of a secondary chain of circles (see p. 54).

The most striking result of this mode of super-position, is the *disappearance of the complementary numbers of the three first groups*, which are all obscured by the addition of the fourth group. If these groups be considered as spheres, the numbers so covered, may be supposed to have no place *on the surface* of the general figure thus composed; and therefore they are not to be taken into account, when we attempt to discover its harmonies, so far as this side of the figure is concerned.

But 32, the complementary number of the fourth group, is obviously before us; and it will be found to correspond with the total of the visible cyphers of the third group, added to the other horizontal cyphers of the fourth, or its own group $(4+3+7+6)+4+8=32$.

The position of 9 in the fourth group is still more indicative of harmonious coincidences. It suggests the ideas of several obvious harmonies; but the most surprising coincidence in which it is concerned, has been already noticed in a previous chapter (see page 54), where the relative positions of 4 and 9 are considered in relation to 49. As we are at present employed in an attempt to discover the origin of the idea of the figure in which this extraordinary development of a *natural decimal system* first occurs, we are now induced to examine the phenomenon in detail. We shall find that independently of the *formal* properties of 49, which led to the construction of a secondary chain of cyphered circles,—its appearance here introduces us to a method of combining parts of a circle in such a mode, that we are gradually brought back to the idea of the first circular table of numbers, with which the original chain commenced.

SECTION III.

On the relations between the quadruple combination of spheres and the first group of numbers in the original chain.

In consequence of a design to construct a solid figure which fulfils the most obvious conditions of abstract simplicity, we bring together two groups of numbers having 4 and 9 in positions which hold no analogy to each other. Our rules of composition are self-suggested in this instance, as they are throughout the scheme ; and our apparently free-will is bounded in every direction by these rules. By following them, we obtain a constant *alternation* of new ideas in regard to form and number, although we commence with no other elementary notions than those of motion, of two points in space, and of space itself. As soon as we entertain the idea of a circular *subdivided* enclosure of space, we attain that of distinct numbers : and their arrangement in relation to previously generated formal circles, suggests the ideas of new forms, which in their turn give rise to still more complicated ideas of numerical harmony. Thus forms beget numbers, and numbers beget ideas of new forms, in a constant but alternating succession ; and although the system becomes at length one of great complication, the principle of *contrariety* is a necessary adjunct which prevails from first to last *(f)*. This is evident, when we contrast the method of generating a circle, with that of generating a sphere, by applying the idea of motion to a diametrical straight line in one case, and to its opposite, or a circumferential line, in the other; at present we are about to show that the numerical idea of 49, itself generated by the apparently accidental contact of two different regions in circular forms, namely, the central point of one, and a circumferential point on the equatorial diameter of the other—promotes the idea of a new complete circle having new numerical properties in relation to the whole scheme, and that it leads us back in a sort of circular progression, to the first notion which we have entertained about inscribing our earliest ideas of proportion or of numerical definition, within the area of a circle.

It was not the least remarkable discovery in our investigation of the harmonies developed in the simple septuple combination of cyphered circles, that 50, the complementary number of the fifth group in that series, should be referable to the four other cyphers of its own circle, and also to the four nearest cyphers of the first or central group of that combination (see page 83). The totals of the four cyphers in each case, expressed the numerical value of a semicircle;—these eight terms of quantity being the joint numerical representatives of a whole circle, which had a numerical value of 50.

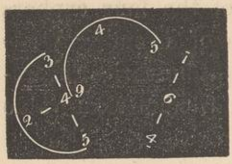
The same mode of deriving the new idea of a circular form from numbers having spacial relations in reference to parts of a circle, enabled us to imagine the existence of a circle having a numerical value of 49, and to make that circle a model group upon which a secondary chain of circular numerical tables was framed. But the essential difference

(f) Although Aristotle seldom allowed an opportunity to escape for depreciating the doctrines of the Pythagoreans, he admitted without hesitation that the abstract force of *contrariety* was universally prevalent, and that it was a productive power throughout the universe, with respect to the generation of new things, out of existing elements.

between 50 and 49 in the two cases, was, that 50 being a complementary number, only served to express the sum total of the eight cyphers *in a supplementary capacity*, while 49 is an idea suggested by the accidental concourse of two cyphers 4 and 9, which must be reckoned as two out of the eleven cyphers which constitute the total of 49.

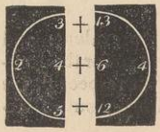
When the secondary chain was modelled upon the group which derived its origin from the formal position of the eleven cyphers in question, three of those cyphers, 5, 9, 4, were combined in one sum, as a preliminary proceeding, and the product, 18, was considered the counterpart of the complementary number of the third group in the original chain (see page 55). The result was most satisfactory, and the consequence was the development of a series of numerical tables, which at last brought us back, by a retrogressive method, to the idea of 1 as our ultimate fractional representative of *a solitary point* in space. But by avoiding this *preliminary consolidation*, we attain the notion of the first numerical table in the other or original chain, which is a result no less extraordinary.

Supposing we adopt another method of treating 5, 4, 9, and combine the elementary portions of the new circle in

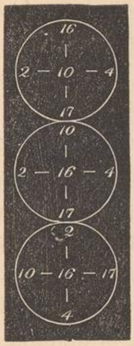


such a way, that these cyphers on the semi-circumference of the fourth group shall each preserve their separate characters, *until the formal addition of the diameter of the third group to the semi-circumference of the fourth*, develops a complete semi-circular enclosure of space;—the necessary numerical combinations will be $5+7=12$, at one angle of the figure, and $9+4=13$, at the other.

We may then proceed to add this cyphered semicircle to the other, taking care, however, to reverse the direction of



the progressive series 12, 6, 13, by making it 13, 6, 12; because its semicircle will be on the right of the new circle. Hence arises a second consolidation of cyphers on the corresponding



diameters: 3 must be added to 13, 4 to 6, and 5 to 12, in order to constitute the three cyphers of the common diameter of the united semicircles.

When we endeavour to alter the positions of the numbers in this new circle, in order to make it correspond with those of a group in the original chain, by attending to the principles on which that chain was constructed,—we find, that, by transposing 10 and 16, we produce a numerical polar diameter in which the central and lower polar cyphers 16, 17, follow each other in the simple arithmetical series which is constant in the original chain.

Then by the simple operation of making this new circle rotate ninety degrees, or one quarter of a revolution on its axis, we have the counterpart of the first circle, if we reject the sign of a decimal power or of an integer from the three cyphers of the horizontal diameter: 10, 16, 17, will then become 0, 6, 7.

In reality, this result only offers the counterpart of the right-hand semicircle of the first group, because the cypher 1, is represented here by 0. But such a conclusion in connection with the idea of 10, as the constant *integral* denominator of 10, 16, 17, is a corroborating proof of the natural influence of the *formal* system, in which 0, and not 1, is the term of unity. (See note, p. 66.)

SECTION IV.

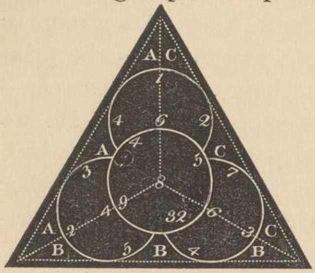
On the constant prevalence of the number 41 on the faces of the two solid figures of four and of five spheres, when their faces are supposed to represent plane equilateral triangles.

The principal harmony in the quadripartite figure now under consideration, is that in which 41 is a dominant number.

We discover it in the sum total of the cyphers on the *polar* diameters of the three first circles which constitute the axis of the figure, for (2+6+4)+(3+4+5)+(4+6+7)=41.

It appears still more surprisingly when we suppose each of the four sides of the quadruple solid combination of spheres to be a *triangular plane*, because it is equally dominant on every side of this imaginary aggregate.

Let us suppose the *horizontal* diameters of the *first*, *second*, and *third* groups, to represent parts of the *angular edges* of the three faces of the triangle, and let us produce these lines, until they meet at 8, the central point of the fourth group. By this mode of dividing the general surface of the diagram into three equal portions, we attain a correct perspective view of the *fore-shortened* three faces of the solid, while the reversed method of drawing the original triple basis will furnish us with the *front* view of the *fourth side* or basis of the whole combination.



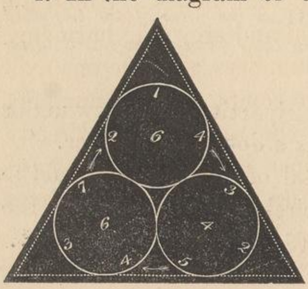
The tangent lines of the figure, although unnecessary appendages to the description of the harmonies of the groups, serve to assist the mind in grasping the formal idea of the solid triangle, at first sight: 32, the visible complementary number, is, of course, not taken into the account.

1. In the face marked A, we find 1+6+8+9+4+2+3+4+4, which sum equals 41.

2. In the face B, 2+4+9+8+6+3+4+5=41.

3. In the face C, 3+6+8+6+1+2+5+7=38+3=41. Instead of the complementary number, 3 is suggested here as a compensating cypher, if we wish to find an adequate balance; and considering the character of the figure, no numerical indicator of form could be more appropriate.

4. In the diagram of the fourth face of the figure, the order of the cyphers must be reversed, and there is no necessity for fore-shortening the outline.



Excluding the highest or complementary numbers, which are visible here, but which would really belong to the interior of the solid, if it were an agglomeration of spheres, we find the same result of 41 as a sum-total, supposing we subtract 6 from 47: for (2+1+4+6)+(4+3+7+6)+(3+2+5+4)=47−6=41.

The subtraction of 6, in order to adjust the sum total of the numbers cyphered on this side of the solid triangle, is in perfect harmony with the progression of the figure. The compensation was not necessary in two of its sides; 3 is added to 38 in the third side; but in the fourth the coincidence is to be obtained by an opposite operation, or the deduction of the simple duplication of 3. Instead of 3 being *added*, 6, or 3×2, is to be subtracted. This is the more remarkable, as 3 and 6 are the two latest numbers in the triple basis (always excepting the complementary 18) which belong to the third and fourth faces of the general figure.

5. The cyphers bordering the internal void of the figure, supposing 8 to be an axis value common to both the spherical poles of the fourth or central group, are together equal to 41.

For 7+8+18+8=41.

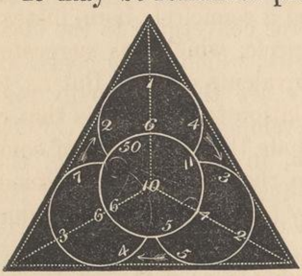
Perhaps this is the most surprising of all the coincidences; because it typifies a centripetal force converging to the ideal point of the figure, which is its centre of gravitation. We are thus gradually prepared for a development of *one of the forces of cohesion*, in the direction of the equatorial diameters of each circle of the triple basis, and of the axis of the fourth sphere, since the complementary numbers belong to the equatorial diameter, and are at the same time the consolidation of its other cyphers, and the signs of quantity which connect one circle with others in several different modes. Under all these circumstances, it is a beautiful and crowning harmony,—that the three complementary numbers and the one axis number, which denote the respective complementary numbers of the combination, should equal the total of 41, already accounted for no less than five times in the simple inspection of the three polar diameters, and the four internal faces of this imaginary solid.(*f*)

(*f*) When 41 is considered as the half of the value of the combination

We may next proceed to apply the same method of calculation to a solid aggregate consisting of *five* spheres. In accounting for the origin of our first ideas of *five* and *two*, as indicators of quantity in regard to separate units, we have already observed, that one sphere added to the four, and so attached to that combination, that it should be opposite the fourth, and on the other side of the triple basis,—will suggest ideas of the two new numbers *five* and *two* (see page 16) as well as that of a new solid form, in which there are five angles, and six equilateral triangular faces.

Let us now place the fifth group of the chain upon the triple basis,—of course reversing the relative positions of its three component circles, as we did in making their under-sides represent the fourth face of the quadruple solid; we shall find the paramount 41, notwithstanding the change of cyphers involved in this mode of calculation, in the three sides of the figure not yet examined. The other three sides have already been inspected in the perfect triangular solid composed of four spheres.

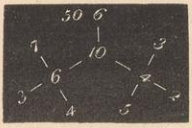
It may be remarked preliminarily, that some of the incidental harmonies of the fourth group are repeated here. The great complementary number 50 (in itself an appropriate adjunct to a form compounded of *five* equal parts) equals all the visible numbers of the second and third groups, and the central numbers of the first group and of its own group.



Thus:—(3+4+5+2)+(4+6+7+3)+6+10=50.

The formal relations of these cyphers when described in their relative positions without the circular lines and other numbers of their respective circles, deserve attention; because their accidental arrangement has the semblance of

(which mode of computation is in accordance with the supposition, that a circular table in the original chain of cyphered circles only represents a hemisphere), we discover that 41 represents 82, the general number so wonderfully developed in the construction of a double septuple series consisting of the first thirteen groups of that chain. (See page 97.)



human invention, while the appearance of 50 in an isolated position, as the equivalent of all the other cyphers united, is marvellously appropriate. The cypher indicating the highest value in this portion of the general figure, is precisely that, which indicates the sum total of the others, and is one of those complementary numbers, which, according to our general rule, cannot be portions of any such combination of numbers, as that of the ten cyphers on the diametrical lines of the second and third circles.

When we revert to the triangular figure, we find that all doubt about the truth of the hypothesis that 4 and 9 in the last figure represent 49 (if doubt could remain), is done away with, by the development of a similar accident in this instance. 6 is so close to 6, that they look like 66, and it will be found on examination that 66 is the total of all the cyphers (except those which are complementary) in the second, third, and fifth groups.

For $(4+3+7+6)+(6+5+11+10)+(3+2+5+4)=66$.

If we formalise this idea, we shall obtain the new forms of *three* semicircles, or of a circle and a semicircle here, instead of *two* semicircles or one whole circle, which was suggested by a similar inspection of the equivalents of 49. But as 49 does not bear the same simple relation to a circle as that of 66 to a circle and a half, we conclude that the value of some distinct portions of 49 differs from that of some constituent portions of the 66, and that they belong to different orders of logarithms.

When we inspect the six triangular faces of the solid quintuple combination, we find the following results.

1. The side D contains the cyphers $1+6+10+4+2+3+11$ $4=41$.
2. The side E contains $2+4+10+6+6+3+4+5=40$.
3. The side F contains $3+6+6+10+6+1\times2+5+7=46$.

Hence it appears that the face marked D is equal in numerical value to the faces on the opposite side of the figure; and if we consider 5 the compensating number here, as 3 was on the other side, we obtain 40 and 41 as the sum totals of the numbers on the other two faces of this side. The face E, which would only contain cyphers equivalent to 40, under such a supposition, is that formed by the highest circles in the figure; but if the compensating number to be added, be 1 there,—and 5 in the next face marked F, be deducted from 46, we should find 41 as the product in both cases. This mode of disposing of the superfluous numbers is strictly in accordance with the formal progression, because the face formed by the connexion between the fifth, the third, and the first circles, is that which may be termed the returning side of the figure, or the last.

It should be remembered, that the basis of the figure offered a total of 47, which was balanced by deducting 6, for reasons assigned elsewhere (see page 119); therefore the progression of the compensation is 6, 3, 5, 1,—a progression which harmonises with the *formal* ideas of the *triple* basis, and the *quintuple* combination.

Thus we have discovered the same sum of 41, as a sum total of the cyphers belonging to a formal portion of this solid, in no fewer than *ten* different places. In three out of the six faces of the figure, it requires no adjustment or compensation. In the other three faces it is adjusted by the balancing powers of 3, 5, and 1. The cyphers on the basis of the solid (which basis consists of three spheres) exhibit a surplus of 6; and when we call to mind its position between the two portions of the solid, the idea of 6 being the connexion between 5 and 3, is in perfect coincidence with all our foregone observations.

The oblong axis of the whole *quintuple* figure is numerically represented by 8 at one apex, and by 10 at the other. Their sum, 18, is the double of 9—a number which, it has been shown, is very influential in the quadruple combination.

When we add this axis number 10, to 41 (the equivalent of 8+7+8+18, which expressed the numerical value of the interior void in the quadruple figure), we obtain a new sum of 51. This number coincides remarkably with the complex result of an operation involving the relations of the two decimal numbers, 49 and 66.

The difference between 49 and 66 is 17; and in the *formal* comparison of the powers of regenerating the idea of the circle, 49 is to 66, *formally*, as 2 is to 3, because two semicircles were suggested by 49, and three semicircles by 66. These two numbers are therefore logarithms; but supposing *the polar diameter of the fourth circle* (valued numerically at 17), to be the formal equivalent of the difference between 49 and 66, which is 17, we find that 17 multiplied by 3 produces 51, *which is the equivalent of the whole centripetal force of the figure.* Twice 17 will produce 34, and if that be the numerical value of a single circle, or of two semicircles, as 51 is of three semicircles, we obtain the following result. The logarithm 66 is to 51, as the logarithm 49 is to 34; while 34 is to 51, as 2 is to 3.

Thus we terminate our enquiry into the harmonious nature of the quadruple and quintuple solids, by fixing upon two numbers as our guides, which are, *humanly speaking*, *accidental* products of the juxtaposition of cyphers in such a contiguity, that they *look like* a *decimal* indication of 49 and 66: and what they look like, they are.

The special location of each of the constituent cyphers of these two numbers,—its precise amount in reference to every other cypher in the combination, and to the sum total of them all,—its special property in regard to all the others, of resuscitating new *formal* notions previously suggested as the foundation of our system of concatenated circles of cyphers, in which it is a constituent,—are abstract facts or incontrovertible truths, the existence of which must be admitted by human reason, even if there had been no material world.

We cannot comprehend the possibility of such truths ever having begun to exist, or of their ever ceasing to prevail in the ideal universe; and yet there is as much fitness in their mutual sympathies, as if they had been invented by the calculating intelligence of our own minds.

CHAPTER IV.

ON THE CONSTRUCTION OF A *TERTIARY* CHAIN OF NUMERICAL GROUPS, AND ITS RELATIONS TO THE ORIGINAL AND SECONDARY CHAINS.

SECTION I.

On the development of a new cyphered circle, which is attained by considering 66 *as a basis number in the quintuple combination of spheres,—this circle being the* model group *of a new chain.*

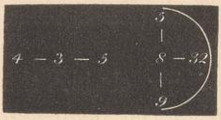
SINCE we discover that the addition of a fifth circular group to the combination of four spheres suggests the decimal notation of 66, precisely in the same manner as 49 was made apparent by bringing 4 and 9 into juxtaposition, we are led to the speculation that 66 will be found to harmonise with the sum total of certain cyphers in its immediate neighbourhood, in the circles which constitute the quintuple series, as 49 did with those of the quadruple combination.

Now it has been shown in the last chapter, that all the cyphers of the second, third, and fifth groups (always excepting their complementary numbers), are together equal to 66; and that they appear in the quintuple figure, as the cyphers of three distinct semicircular arrangements.

The central number 10 of the whole combination is taken into the calculation here, which was not the case when the equivalents of 49 were discovered in a similar manner in the quadruple figure. It is a desideratum, therefore, to construct an entire circle by combining the numerical powers of these three semicircles, without reducing any of their cyphers to lower quantities by an arithmetical process, *and to make this circle of five cyphers the model group of a new chain.*

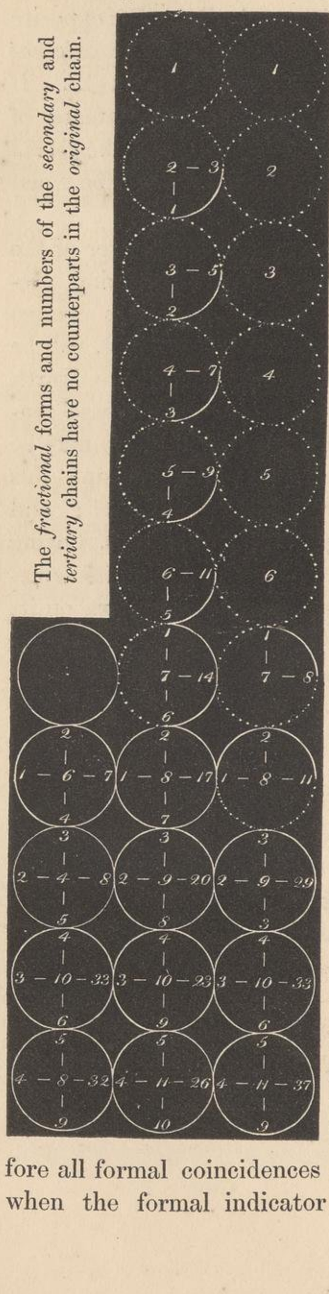
In the successful endeavour to produce the model-group of the *secondary* chain, it was discovered, that the opposite semicircles of the *second* and *third* groups of the *original* chain contained the cyphers which coincided with 49. If we adopt an analogous method, and combine the diameter of the *second* group with the right-hand semicircle of the *fourth* group, we shall find that their cyphers will together be equal to 66.

When we change the position of the polar diameter of the *second group*, as was done before (see p. 55), having previously made its upper polar and central cyphers change places,—we shall find, that its lower polar cypher, 5, will be applicable to 32, the complementary number of the fourth group, and that their sum will be 37. The transposed central number of the second group may be added to that of the fourth group ; this will produce 11, for 3+8=11 ; and a new circle will be constructed, having 4 and 37 at the two ends of its equatorial diameter, while the cyphers on its polar diameter will be 5, 11, 9. Its five cyphers will give a sum total of 66.



Now this circle will be a pivot, *both as regards a retrogressive and a progressive method of deducing circles from it*, which that having its five cyphers equal to 49, was in the secondary chain : its position in relation to that chain is determined by its formal indicator, 5, which denotes that it is on the same parallel as the *fifth* formal circle of the original chain. We shall also find that this new corresponding group has the same value on *its polar diameter* as that of the *lower left-hand quadrant* of the corresponding group of the secondary chain ; —for 5+11+9=4+11+10=25 :—and, that its complementary number, 37, is equal to 11+26, the central and complementary numbers of the parallel circle in that secondary series.

We may, therefore, select these two harmonies as guides for the construction of the new chain, in regard to its progression and retrogression: and it will be found that the central cyphers on either side of the pivot will be values, diminishing in an arithmetical ratio, from 11 to 1. Hence it is evident that this chain is a finite one in both directions, which was not the case with respect to the *progression* of the *original* or the *secondary* chain, as they were both capable of an infinite extension, in that direction.



The *fractional* forms and numbers of the *secondary* and *tertiary* chains have no counterparts in the *original* chain.

In this *tertiary* chain, the tenth group from the pivot will exhibit 1 as its central number, as regards the other cyphers of the same group *in the progression;* while the tenth in the *retrogression* will be reduced to the solitary idea of 1 unaccompanied by any other cyphers, and consequently to an ultimate *informal idea.*

The same conclusion was obtained, when the ultimate idea of the *secondary* chain was the numerical unit: but in this *tertiary* chain all the central cyphers of the retrogression are solitary, after the cessation of the parallelism, as may be seen by inspecting the diagram: therefore all formal coincidences of the parts of a circle vanish, when the formal indicator disappears in this chain, and instead of quadrants of a circle, we only meet with a succession of points, as the representatives of circles, or parts of circles.

The result suggests a new idea of points having different values when they are not inscribed in a circle: and here, for the first time, do we obtain the notion of numbers in the abstract, which have no other *spacial* conditions than those of the distances between the centres of circles. This conclusion is the most satisfactory proof of the complete correctness of the scheme; because this single spacial condition of a distance between points, is the simplest idea of form, to which the outline of the circle itself is attributed as an elementary principle, when we generate that notion of a perfectly uniform enclosure of space, by applying the abstract vivifying influence of motion to the definite straight line.(*a*)

(*a*) The fitness of the whole scheme, even in its most minute particulars, appears in this idea of a distance between *two points having different values*, being equal to two radii of different circles having their arcs in contact. It must be remembered, that when we attained the idea of a second circle, that of an ellipse was the coincidental discovery,—but that the whole elliptical figure gradually collapsed upon the line which connected its two parent circles, as soon as they became distinct circles connected by their circumferential outlines. (See the introduction to book I, p. xxxiii.) This limited distance between points, which are the centres of circles described in our diagram by circumferential *dotted* lines, (because they are not indicative of *formal* attributes,—as circles, semicircles and quadrants are in the groups of cyphers), furnishes us with the elementary idea of a *limitation* as to distance, between two points in space, which was an original desideratum; —the *first* circle depending upon it for its original magnitude.

But we now find unconnected spacial points, all holding the same fixed relation of distance to each other, which equals the diameter of the first circle. It is true that this offers no idea of *absolute* size; but it maintains the notion of the prevalence of one magnitude as regards all the circles of the scheme; and brings us back to the first idea of the distance with which we commenced.

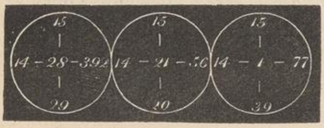
In a subsequent chapter, where there are some preliminary speculations upon differences in the forms of ultimate material atoms, it is part of the surmise, that the *equatorial circumference of every atom (be its volume what it may), is the same* throughout the physical world,—and that there is but one circular *model* or type of an atomic equator, so far as a *superficial* outline of every atom is concerned, although the form of the atom may be different in every different simple chemical substance.

SECTION II.

On the limited character of the tertiary *chain, and the comparison between its final circle and the parallel or corresponding groups both in the* original *and* secondary *chains, which may be extended* infinitely *by a progressive method of increasing the values of the cyphers by which they are represented.*

It has been remarked in the foregoing section, that this tertiary chain is finite in both directions. The model-group having 11 as a central number, is preceded and succeeded by circles in which the central cypher is 10; and the 15th formal group, which is the 10th from the pivot in the progression, will exhibit 1 as its central number, and thus indicate a termination of the chain.

When the parallel-groups in the original and secondary chains are compared with this final-group, we find a beautiful development of the general harmony.



1. The central numbers are 28, 21, 1. That of the original chain is the value of the fractional semicircle at the head of the *secondary* chain, where 28 is represented by 1, 7, 6, on the polar diameter, added to 14 its complementary number. That of the secondary chain, or 21, is in harmony with the total of the cyphers in the second group of the original chain, which exhibits a total of 20, the 1 being indicative of the second series or chain in which 21 appears.

That of the tertiary chain is 1, which indicates, that it is the first complete circle,—*reckoning back* from this group to the model-group of its own chain.

2. The lower polar numbers are 29, 20, 39. Of these, the two first are together equal to 49, or 7 × 7, the great number of the system. But if we add the central 1 to the 39 of the tertiary chain, we have the double of 20, or 40, in the same position at the lower pole of the secondary chain, supposing 1 be treated as a fractional unit: should we consider it a decimal integer, and value it as 10, its addition to

39 will give 49 as a product, which is the corresponding cypher in the original chain.

3. The complementary numbers are 392, 56, 77. If we divide all the numbers 392, 56, 77, by 7, we have 56, 8, 11.

Therefore, if the complementary number of the 15th formal circle in the original chain be divided by 7, the product is 56, the complementary number of the 15th circle in the secondary chain—a most harmonious result, when we call to mind, that the 56 in this place in the secondary chain, was produced by adding 7 to its numerical denominator 14,—and by taking the double of the product, or 42, as a sum to which the 14, or basis number, was to be added in order to obtain 56. For $14+7\times2+14=56$.

But if we examine the fifth formal circle in the original chain, we find that its central cypher is 8, which is the result of dividing 56 by 7, while the central number of the fifth group in the secondary chain is 11, which is the result of dividing the highest complementary number of the tertiary chain, or that of the 15th group in it, by the same quantity or 7. For $77\div11=7$.

4. The respective totals of the five cyphers in each of the parallel circles, which may be called the fifteenth as regards the original chain, are 478 in that chain, 126 in the secondary chain, and 146 in the tertiary chain. If we divide 478 by 126, the result is $3\frac{100}{126}$: if we divide 478 by 146, the result is $3\frac{40}{143}$: the relation of the numerators of the fractions in these two cases, is 100 : 40, which is precisely that found in the table (page 66), where the numerical indicator 5 gives 100 as the corresponding fraction of its own chain, and 40×7 as that of the parallel circle in the secondary chain,—such circles being the *fifth* in both. Hence it appears that all the harmonies refer us to the fifth circle, or to that which is the model-group of the tertiary chain.

Finally, no number could have been so appropriate as 77 in the position which it occupies in the tertiary chain, where it is the last and highest. The harmony of its appearance in this place is most striking, when we remember that it belongs to a series of circles, in which the pivot or model-group was first suggested by 66. It is difficult to conceive a system more indicative of symmetry than this chain, in which the model form has 11 as its central cypher, while each of the two *termini* of the series has 1 as the ultimate number; that term of unity denoting a mere mathematical point in its fractional capacity at one end, but representing a centre of a defined circle as an integer, at the other.

The quantity of special or distinct formal ideas in this chain, is 21, which number is itself indicative of 20, the value of the first quadrated circle in the original chain, added to the fractional unit; while that identical number 21 is central to that circle in the secondary chain, which is parallel to the circle in the third, where 1 is the central cypher, and 77 is the highest complementary number of the chain itself.

It is one of the rules observed in constructing the chains of circles, that the central cypher is indispensable, even if all the cyphers on the circumference should disappear. This happens in only one instance in the *secondary* chain, when we attain the last idea of 1 as the value of a central point: in the tertiary chain it occurs as soon as we pass the parallel of the blank circle at the head of the original chain, and we obtain distinct ideas of six mathematical points in the retrogression, numbered 6, 5, 4, 3, 2, 1, respectively, which have no other *formal* relation to each other and to the chain to which they belong, than the distances between them (*b*).

It would therefore be inconsistent with the whole theory, to suppose that this *tertiary* chain could be extended beyond the parallel of the fifteenth formal circle, or the fourteenth numerical group of the original chain: when we attain the idea of 1 as the central cypher, we reach that limit.

Even as regards the *parallel group of that secondary chain*, there are indications of a peculiar harmony; for its comple-

(*b*) The idea of a difference between forces located on mere spacial points, and of *positive* and *negative* relations is first suggested by this chain, without the necessity for placing the equivalent numbers in the same circle. It therefore became important to demonstrate its peculiar qualities. The concluding plate of this book is a diagram of the three chains brought into juxtaposition, in a manner which offers a synoptical view of their harmonies.

mentary number, 56, is the fractional value of a complete circle, in its own chain, while its lower polar cypher, 20, holds a similar relation to the fractional equivalents of the complete circle in the original chain. See table, page 66, where 1. . . . 20 . . . . 56 are coefficients (*c*).

SECTION III.

On the general harmony between the original, the secondary, and the tertiary chains.

WHEN we revert to the original idea of the circular form, and our method of creating it in the mind by attributing motion to two points, which are always at the same distance from each other, we discover that it is only necessary to suppose each of them to describe a semicircle, in order to obtain the ideal form of two connected semicircles. (See pages xlvii and xlviii, Introd. Book 1.) If, therefore, we are content with this process, we find that the entire blank

(*c*) In constructing this chain it should be remembered, that its upper polar and left hand equatorial numbers of the complete circles, are the same as in the parallel groups of the other chains. The central cyphers are suggested by the position of the group on either side of the model circle, and its central number will denote its distance from that model in mere arithmetical progression or retrogression. Its lower polar number will be greater or less than that of the preceding group, by 3. In the model group it is 9 ; therefore it will be 12 in the next of the *progression*, but only six in that which precedes the model, or in the next of the *retrogression*.

The complementary number will be found by *adding* 4 to that of the preceding group in the *progression*, or by *deducting* 4 from it in the *retrogression*, so long as we have five cyphers in it. But when the circle is incomplete, the complementary number is found by adding together all the other cyphers in it. This only occurs in the groups which correspond with the blank circle and first quadrated circle of the original chain ; in the remainder of the retrogression, all the other available cyphers, except that at the centre, disappear, and as, according to our general rule, there can be no complementary number where there is no product,—it would only be found in the quadrant of this chain, which is parallel to the blank circle of the original chain. In the fractional portion of the secondary chain there are five such quadrants, and their adjustment in a new circle has been examined at length. (See the section commencing at page 70.)

circle may be considered as a compound made up of the two semicircular lines; and this tallies with the corresponding group of cyphers in the secondary chain, representing a semicircle only. (Plate 1, fig. 3.)

But as the first conceivable method of so applying an ideal motion to two points, necessitates the construction of the *whole circle*, one point describing one half of its outline, and the other point describing the other half,—it can only be represented by 1 or by 0, as its integral cypher, *because we cannot divide the integer in its formal capacity*. The only way of representing it by fractional figures is indicated in the original chain itself, where 10 is its *inferred* representative, in relation to subsequent circles in that chain.

It has been already shown in the same section, that if we suppose two opposite points, on the circumference of a pre-existing circle, *to move towards each other*, they must at last be in contact, and eventually pass each other. It is evident that they would then hold the same fixed relation to each other, as that of two radii of the same circle, and that although its centre would be the graphic representative of a new stationary element in the problem (which was not the case when the original circle was first described, notwithstanding the partial rotation of the imaginary line between the points. See page 30), the *unbroken diameter* would not, in such a case, be the regulator of the motion, so far as the distance between the moving points is concerned.

In the *tertiary* chain we only find a quadrant on the parallel of the blank circle of the original chain, or of the semicircle of the secondary chain: and this mode of comparison interferes with the general harmony of the three chains. But if we still persist in regarding 10 as the only allowable fractional denominator of the original blank circle, and as the equivalent of 28 in the parallel semicircular group of the *secondary* chain,—we discover that the quadrant in the *tertiary* chain may hold the same relation to 5 in the original chain, as the semicircle in the secondary chain does to 10, although the cyphers in that quadrant are 1, 7, 8, or 16.

Therefore the fractional basis of the secondary and tertiary chains have *formal* as well as *numerical* relations to the *numbers* of the original chain. When they are considered as distinct systems, the corresponding fractions in the three chains are 10, 28, 32, or 20, 56, 64. But when the forms of the parallel blank circle in the *original* chain,—of the semicircle in the *secondary* chain,—and of the quadrant in the *tertiary* chain,—*are all referred to the numbers of the original chain*, their different values are all reduced to one numerical ratio, in which 5 is the number of the quadrant, 10 is that of the semicircle, or the circumferential line of the blank circle, and 20 is that of the whole quadrated circle.

We have already found, that when the cyphers of the original and secondary chains are treated as logarithms, each cypher in a circle is the representative of some value, which is not expressed in terms, but which will explain the general harmony of the whole system: this harmony is based upon the fractional value of 1 (as an integer) being represented by 20. See chap vi. book 1, p. 63.

In such a scheme, the integer in question is the equivalent of a complete quadrated circle, and it is perfectly consistent with the whole plan, that any *integral* term *less than* 1, can only be 0; but as we imagine parts of a quadrated circle, we may define those parts by *fractional* terms of relation to the whole circle.

But we have seen, that the method of numerical definition exhibited in the original chain, obliges us to adopt 20 as the fractional denominator, and that the progression advances in the ratio of 20, 40, 60, 80, 100; while the retrogression gives 10 and 5, as the respective equivalents of the semicircle and and quadrant (but by inference only), when we reduce the basis values of the complete circle in the secondary and tertiary chains to the numerical plan developed in the original chain.

The whole scheme, complicated as it may appear, is therefore a perfectly harmonious system; and when it is remembered *how* these regular results have been developed, it cannot be objected, that any one of them has been attained by a desire on the part of the author to accommodate the various and successive processes by which he has reached them, to a previously-imagined conclusion.

Nothing at first sight could have been more unpromising than the basis-series of numbers, 2, 4, 7, 1, 6, 3, 4, 5, 2, with which the system commenced, so far as *precedence* is connected with the ideal development of each of those numbers in the mind. Yet by following the self-suggested rules of attributing the origin of every *new* idea of number and form which has been successively exhibited in the argument, to previously-existing forms and numbers,—and by always bearing in mind that in the application of *motion* and *rest*, there must be an alternation of these conditions, and that whenever the doctrine of *contraries* can be brought to bear upon the scheme, it must be so applied,—we have at length arrived at such a stage in the gradual creation of ideas of abstract forms and relative quantities, that we may proceed to examine nature with the object of discovering whether the same method may have been made manifest in the material world.

We pause here, because we have already fulfilled the task proposed in this book of the general treatise, and applied the mathematically-generated system of numbers to the abstract series of formal images by which those numbers were originally suggested. The images in question are, the single and double septuple figures composed of seven and fourteen circles,—the quadripartite solid, in which the first four quadrated circles representing spheres, are brought into contact in the most compact manner,—and the pentagonal six-sided solid, in which the *first five quadrated* circles are similarly employed.

It is obvious that the numerical theory advanced in this work, is capable of being carried out to a much greater extent; indeed it is difficult to say in how many directions, and to what complicated system, it may not be applied.

ESSAY IV.

ON THE MOST OBVIOUS METHOD OF APPLYING THE GEOMETRICALLY-DERIVED SERIES OF NUMBERS TO CHEMICAL PHENOMENA.

SECTION I.

General considerations on the variable conditions of ultimate *atoms. Introductory.*

In two preceding essays, an attempt has been made to lay down the outlines of a consistent physical system, and of a geometrically originated scheme of numbers. In the present essay it is proposed to apply the numerical series to some of the most simple chemical phenomena.

We have supposed, that the ultimate atom is a material entity, which has the conditions of limited existence common to all generated beings;—that it undergoes changes of form; —that, when its polar diameter is longer than the equatorial diameter, it is acted upon by other oblong atoms *repulsively*; —that when its equatorial diameter is the longest, it is acted upon by other oblate atoms *attractively*;—that the mutual attraction of *spherical* atoms is the first manifestation of that force, which is called *centripetal* by natural philosophers, and that such atoms only unite in indefinite quantities, but that all oblate atoms cohere (independently of the centripetal force) with a fixed quantity of similar atoms, in accordance with specific laws affecting the numbers which constitute each penultimate particle of a simple body.

It has been surmised, that the class of substances called *ozone* are composed of individual *oblong* atoms,—that *hydrogen* consists of *spherical* atoms,—and that all other chemical bodies are aggregations of particles, each particle containing a fixed number of *oblate* atoms, which varies relatively to each sort of ponderable substance.

It has also been inferred, that all oblong atoms have a tendency to disperse in space in obedience to a law, which enforces their mutual repulsion, unless they are affected by their *opposites*, namely particles composed of the *oblate* atoms,—that every sort of combination of these oblate atoms, holds an *elective affinity* to a peculiar form of the *ozonic or oblong* atoms, which may be liberated by the chemical separation of aggregated particles from each other, and may either be then compelled to radiate (*apparently*) in space, in consequence of their own mutual repulsion, or may be at once combined in another mode with some new chemical aggregation of such oblate atoms;—but that (considered *absolutely* without reference to these particles, composed of oblate atoms) every *oblong* atom is distinctly separate from every other,—and that the action of their mutual repulsion will account for the appearance of *centrifugal radiation.*

Next, as regards hydrogen (which is assumed to be an aggregation of atoms having a spherical form), its ultimate constituents are supposed to hold the double relation of *ultimate* and *penultimate* molecules to the constituents of all other simple bodies,—and that as regards occupation of space, they offer a medial starting point for the analytical chemist, since every other constituent of a chemical body, be it an oblong or oblate atom, must be smaller than the sphere.

Hence, we may assume that in our general scheme, the ultimate constituent of hydrogen is to be treated as *unity,*—and that the practical application of the numerical system in the first instance is one of *fractions,* with respect to any given quantity of space represented by the spherical atom of hydrogen.

According to this doctrine, the *aboriginal* elementary *data* are the same in every case, and the *absolute* gravitating force of every atom (be its size what it may) is the same. Every spherical atom is assumed to have the same bulk; but the *relative* gravitating force of each atom will depend upon its greater or less occupation of space which may have been occasioned by the increase of its oblateness.

It must be remembered, however, that the mutually attractive force in question is the measure of mere centripetal gravitation, but that this is interfered with by all those special elective ordinances, which it is the province of the chemist to determine,—that the graduated tendency of each atom to contract is regulated by laws, which offer some definite limits or stages to certain self-developed changes in its form;—and that although the change is continuously in one direction as regards the conversion of the oblong spheroid into a sphere, and of the sphere into an oblate spheroid, it is not supposed to occur *imperceptibly*, but by a sudden expansion or contraction from some one point in the fractional scale to another.

Such being the basis of the general physical hypothesis, our present object is to demonstrate that these sudden changes hold a wonderful relation to the geometrically derived series of numerical circles, which have been described in the preceding essay.

A due consideration of the physical hypothesis will lead to the inference that all *oblong* atoms must be still about to undergo a change, which will convert them into perfect spherical molecules, throughout the solar system, or any other given region of space in which they may exist. On the other hand, the argument suggests, that every oblate atom which is now the constituent of any heavier substance than hydrogen, must have passed through the ozonic and hydrogenic stages of its graduated change. It also follows, that at one time no heavier substance than hydrogen could have existed within the spacial region now occupied by the solar system, unless we suppose, that the primal development of distinct atoms is a continuous and unceasing process of Nature throughout Infinite Space.

If hydrogen be composed of perfect spheres, and the proportionate size of every heavier substance holds a relation to the peculiar stage of contraction of its oblate atomic constituents, we might hope by accurate investigation to discover the *form* of each atom, although our analytical processes will never enable the practical chemist to ascertain its absolute bulk. The problem would be strictly one of geometry,—supposing that each atomic individual were always an elliptical spheroid, and that whatever might be the eccentricity of the ellipse, its *sectional outline* were a *constant quantity*, notwithstanding the variations in the length both of its major and minor axes.

Such a problem might be solved without reference to the doctrine, that each particle or the specific aggregate of atoms in each such *penultimate* molecule of a simple chemical body, consists of some *definite* number of ultimate atoms. But when we endeavour to discover why the quantity, be it what it may, is thus limited,—we are engaged in an arithmetical as well as a geometrical or formal enquiry; and the scheme of geometrically-originated numbers already explained in the preceding essay, may assist us in the solution of the problem.

SECTION II.

On the application of the first circular group of geometrically derived numbers to the relations between the equivalents of Hydrogen, Carbon, Nitrogen, and Oxygen.

Before we proceed to apply the circular categories of our chains of numbers to chemical phenomena,—it is necessary to recollect that 2 and 4, the first and second ideas of quantity in the whole series, were suggested as *fractional* terms, expressing the halves and quarters of one formal integer: but the other three cyphers of the group,—namely, 1, 6, 7,—denote ideas elicited by the observation of a septuple compound figure consisting of seven different but equal circles. The inference is, that 2 and 4 would be powerful types, not only as regards the specification of quantities, but of division and multiplication.

For instance, we find from chemical observation, that the specific gravity of nitrogen, supposing hydrogen to be unity, implies that 14 atoms of the one are requisite to fill the space occupied by a single atom of the other, while that of oxygen leads to the conclusion that the atom of hydrogen equals in bulk 16 atoms of oxygen. With respect to spacial division therefore, we discover that the ultimate atom of nitrogen is represented by $\frac{1}{14}$, and that of oxygen by $\frac{1}{16}$, in relation to the ultimate atom of hydrogen: but when these numbers are considered in reference to the force of gravitation, 14 and 16 must be treated as indicatives of the quantities of distinct ultimate atoms,—if there be any truth in the generally admitted hypothesis that different weights in relation to any one given spacial region, are the indices of corresponding numerical quantities of distinct individuals, whose *absolute* weights or powers of attraction are equal.

Now, when we examine the first cyphered group of the chain, we find that there is an obvious connexion between 7 and 14, as well as between 4 and 16. We also observe the requisite term of duplication 2, as regards 14, in the same circle, where it occupies the highest position, while 4, the square root of 16, is in the opposite position. But the other three cyphers in the group,—1, 6, 7,—being originally suggested as integral numbers, are not to be considered as terms of division or multiplication; they can only be treated as multiplicands, according to the strict application of the hypothesis.

Hence it appears, that in the first circular group of numbers, 2 is only applicable as the type of a duplicating or halving power, as regards other numbers: but 4 expresses both the multiplicand and multiplier in relation to the specific weight of oxygen when compared with hydrogen, which is 16; and it not only applies to the mode in which the 16 atoms of oxygen are to be divided, but it specifically points out the equivalent of that substance, or the number of ultimate atoms, which constitute each of *its penultimate particles,* in the same way as the central cypher 6 does with respect to the generally admitted equivalent of carbon.

The admirable harmony thus shown to exist between the first group of our numerical chain, and the four simple substances, which are so largely concerned in the constitution of this planet, will be perfectly understood, when we remember that in reference to *volume* or *outline*, (the atom of hydrogen being supposed to be the basis size, as a perfect sphere), the particle of oxygen will correspond with *one fourth* of the circle which is represented by the *quadrating* number. In the abstract numerical scheme, 4 holds the same relation to 16, as that of a *quadrant* to an entire circle. Thus the particle of oxygen consisting of 4 atoms will practically occupy one fourth of the whole volume which may be filled by a single atom of hydrogen,—by 6 atoms of carbon,—or by 14 atoms of nitrogen; oxygen therefore stands apart among the four substances in question, in consequence of this practical *quadrature* of the total typical number expressing its specific gravity, (*a*) while carbon and nitrogen may be conjectured to exist in *penultimate* molecules, each of which is the combination of the same number of *ultimate* atoms as are expressed by the terms of their specific gravitating relations to hydrogen.

From this mode of reasoning, it appears that the only cypher of the first group of numbers, which is not represented in the list of hydrogen, carbon, nitrogen and oxygen, is 2, and that this number is itself the first idea of quantity suggested in the geometrically-derived series of numbers.

(*a*) The reader should remember that the basis of the whole scheme of chemical proportions, is the relation between *weight* and *volume*, and that the only obvious method of explaining the differences of specific gravity of different substances, is to assume that every ultimate atom, be its volume what it may, *has the same weight.* When therefore the elementary cause of such differences is reduced to its last relation, it can only be a difference in the *ultimate atomic* constituents of bodies.

Having thus arrived at a definite notion, with respect to the arithmetical quantity of individuals in each *penultimate* molecule or specific *particle*, let us next endeavour to discover the *formal* modes of their combination. According to the general hypothesis, the ultimate *single* atoms of hydrogen are practically particles, holding the same general cohesive relations to each other as they do to the *aggregated* penultimate molecules of every chemical substance which consists of *oblate* atoms. The form of each atom of hydrogen is assumed to be a sphere, and such spheres are supposed to be held in union with each other or with the penultimate molecules of other bodies, by a cohesive force differing *generically* from that which occasions the cohesion of oblate ultimate atoms in their respective specific particles. This sort of cohesion may be interfered with, either by chemical analysis, or by a mechanical force.

In Nitrogen, on the contrary, the ultimate atoms may be kept together by some more energetic attraction in penultimate double molecules, each molecule consisting of two layers, and each single layer realising the abstract geometrical union of *seven* circles in the most compact mode ; two septuple layers of *oblate* spheroids, so arranged that the interstices between any two atoms in one layer should be partially filled up by the intrusion of one in the other layer, will present us with a practical demonstration of lateral as well as of superficial compactness. Unless each complete particle of nitrogen consisted of 14 atoms, the combination of 7 would have a superficial character: but there is a valid reason for assuming, that in every penultimate aggregate of atoms, they must be at least two deep in every direction.

As regards Carbon, if 6 be its practical equivalent, two triangular combinations might be imagined to be connected in the same way as the two septuple ones have been in nitrogen.

That the simple arrangement of two layers (with *three* atoms in each layer), is the mode of aggregation of the ultimate constituents in the particle of carbon,—would accord with the idea of compactness being an elementary condition of molecular union, so far as its application to practical combination is compatible with the *specific* form of each ultimate atom in the aggregate.

Lastly, with respect to the *form* of the *oxygen* particle (supposing it to consist of *four* ultimate atoms), the most obvious model of their aggregation would be that of a solid equilateral triangle, if they were all perfect spheres; and this mode appears the most reasonable, even if we admit that they are oblate spheroids, although the result would not be the production of a form so completely harmonious.

We have thus speculated upon three of the most simple modes of realising the agglomeration of six, fourteen, and four spheres or spheroids, in those *double triple*, *double septuple*, and *pyramidical quadruple* combinations, which have been already suggested to the imagination with respect to form in the abstract; and we find that they ought to be placed in the first numerical circle of our chain in the following order:

Hydrogen.	Carbon.	Nitrogen.
1	6	$7 \times 2 = 14$
	Oxygen.	
	4	

It may be shown, that another of the generally-admitted simple bodies, which is largely concerned in the processes of Nature, (namely *chlorine*, some of whose properties resemble those of oxygen), has a specific gravity, which exactly coincides with double the four cyphers in the first numerical group,—the other cypher, 2, being treated as the indicator of their duplication. We find $(1+6+7+4) \times 2 = 36$, the total being the term of the specific gravity of chlorine in relation to hydrogen.

Chemists have generally determined, perhaps without sufficient data, that 36 is the equivalent, in other words, the definite number of ultimate atoms in each penultimate molecule of *chlorine.* In this respect they may have been guided by the same method of reasoning, as that which has induced them to attribute 8 to oxygen. It will be seen, that 18 (the complementary number of the *third* group of cyphers in our chain), holds the same relation to equivalents of chlorine in its combination with other substances, when it is doubled, as 8 the complementary number of the *second* numerical circle, does to the double equivalent of oxygen.

We must suppose, however, that *if every ultimate atom has been previously one of hydrogen*, which is a basis-postulate in our hypothesis, the diminution of the volume necessary to account for a reduction to $\frac{1}{30}$ of the original bulk, must have been a result of a much longer continuance of the process of contraction, than would account for the development of those larger forms of the ultimate atom, which may constitute portions of the penultimate molecules of carbon, nitrogen, or oxygen. Hence it follows, that according to such an hypothesis, chlorine could not have existed in this planet until after the formation of these substances, and most probably of some of their respective compound corpuscules. This notion is supported by the inspection of the chain of numbers, in which the third group or circle may be specially referred to chlorine, and its union with them, or with their compounds.

Bromine, iodine, and fluorine,—all which, like oxygen, have the peculiar property of supporting combustion, although their specific gravities are greater than that of chlorine—may be in a like manner compared with still lower groups or categories in the chain.

Let us now proceed to the consideration of the compounds of hydrogen, carbon, nitrogen, and oxygen, in reference to the geometrically originated numerical system.

SECTION III.

On the simplest binary compounds of Hydrogen, Carbon, Nitrogen, and Oxygen, in reference to the first circular group of numbers in the series.

In accordance with the notion of a progressive change in the form of the ultimate atom, we have supposed, that hydrogen existed within the limits of the solar system before carbon, carbon before nitrogen, and nitrogen before oxygen. Their earliest *binary* compounds may therefore be imagined to have developed themselves in the following order.

1. Hydrogen and Carbon.

2. { Hydrogen and Nitrogen.
   Carbon and Nitrogen.

3. { Hydrogen and Oxygen.
   Carbon and Oxygen.
   Nitrogen and Oxygen.

The lowest series of proportionals which have been discovered by the analytical chemist, may be arranged as follows with respect to these combinations.

1. 1. Carburetted hydrogen. H 1 + C 6 = 7.

2. { 2. Ammonia. H 3 + N 14 = 17.
   3. Cyanogen. C 6 + N 14 = 20.

3. { 4. Water. H 1 + O 8 = 9.
   5. Carbonic Oxyde. C 6 + O 8 = 14.
   6. Atmospheric Air. O 4 + N 14 = 18.

When we examine the above classification of binary compounds, we observe a striking coincidence with the relative arrangement of the cyphers in the first group of the chain. A corpuscule of *carburetted hydrogen* consists of one atom of Hydrogen and six atoms of Carbon. The total 7, in the first circular group of numbers, is the exact local representative of that substance, supposing a cypher to represent the word.

It must be remembered that if our physical hypothesis be correct, the formation of carburetted hydrogen (*b*) must have been the earliest result of the combination of two simple chemical bodies. In this instance the coincidence between the chemical arrangement and that of the numerical succession in the circle is complete: the corpuscule of carburetted hydrogen consists of 1 atom of hydrogen and 6 atoms (or 1 penultimate particle) of carbon, $1+6=7$. Hence the three distinct bodies which are supposed for physical reasons to have existed the first in any given region of space,—namely, two simple substances and their compound—are represented by the cyphers on the equatorial diameter of our first group of numbers, as a sum in addition.

The same parallelism of proportionals appears with respect to Nitrogen. By the rule of addition, $1+6+7=14$, which number denotes both the molecular equivalent and the relative gravity of that body. When applied *formally*, the equivalent of nitrogen is represented by the entire diameter of the circle—that of carburetted hydrogen by the radius line between 1 and 6—that of carbon by the central point—and that of hydrogen by the point on which the cypher 1 is located in the circular group of numbers.

So soon as nitrogen was developed, but not before, two new compound bodies resulting from its combination with hydrogen and carbon, might have made their appearance. The first of these is *ammonia;* the other is *cyanogen.* In both cases we observe proofs of the harmony between our physical and numerical systems.

(*b*) The term Carburetted hydrogen has been used in the text, in reference to that binary compound of Hydrogen and Carbon, each corpuscule of which consists of one particle of Hydrogen and one of Carbon. The term may be one of general application to all compounds of these two substances, but as chemists are undecided to which compound it should be applied, the author has thought it necessary to explain that he does not mean the species of Carburetted Hydrogen which contains two volumes of Hydrogen in combination with one of Carbon, but that in which the respective volumes are equal. The latest observations lead to the inference that a combination of *one* particle of one, and *one* of the other, does exist in Nature.

The equivalent of ammonia is 17. Its corpuscule is a combination of 3 atoms of hydrogen and 14 atoms (or 1 penultimate particle) of nitrogen. Taking the cypher 2 on the upper circumference of the circle, as the sum to be added to 1, the total 3 appears as the *numerical* quantity of atoms of the hydrogen in the corpuscule of ammonia. When considered *formally*, we have before us the arc of the quadrant between 1 and 3 as the *linear* representative of the hydrogen, and the diameter (or two radii) as that of the nitrogen. The *formal* result is the image of *a quadrant of a circle.*

The equivalent of cyanogen is 20. Its corpuscule is a compound of 6 atoms (or 1 particle) of carbon and 14 atoms (or 1 particle) of nitrogen. We have seen that the central cypher of the group represents the equivalent of carbon; but the same number results from adding together 2 and 4, which are at the two opposite ends of the polar diameter of the circle.

When treated in this manner, a semi-circumferential arc is indicated *linearly* by 2 and 4, in the same way as that of a quadrant was shown by 1 and 2,—or as that of an entire diameter of the circle was by 1, 6, 7. The *formal* addition of the semi-circular arc to the diameter, suggests the figure of a complete semi-circular space bounded by its diameter, as the *linear* type of cyanogen; while that of ammonia is a complete quadrant of a circle.

Another coincidence is found in the fact, that the cyphers on the circumference of the circle $2+1+4+7=14$, the equivalent of nitrogen, while the cypher indicating the central point of the circle represents that of carbon. The combination expresses the total of all the cyphers in the circle having a joint value of 20.

Thus we find a double harmony:

1. The semi-circular arc represents carbon—the diameter, nitrogen—the combination of the arc and the diameter, or the completely enclosed semi-circle, cyanogen.

2. The central point represents carbon—the whole circumference, not taking that central point into account, nitrogen, —the complete circle with the central point, cyanogen.

If it be a correct doctrine, that the *practical* chemical development of new substances, is regulated in obedience to the same mathematical laws, as those which prevail *necessarily* with regard to the harmony of our geometrically-derived numerical circles,—we discover an obvious reason why three equivalents of hydrogen should be combined with one of nitrogen in the corpuscule of ammonia. The same law which has been proved to prevail as *an abstract necessity* in relation to the reconstitution of semi-circles and circles in consequence of the self-suggested development of numbers originally deduced from circles (see page 85), will account for the proportional parts of the hydrogen and nitrogen in the ammonia being what they are. Our first expectation would be, that one or two equivalents of hydrogen at most should be discovered in the corpuscule of so early a substance as ammonia: the presence of three atoms of hydrogen in the compound appears to offend against our idea of gradual arithmetical progression: but we find an explanation of the cause of such an apparent anomaly, in the relative values and circular arrangement of the cyphers.

As regards the six substances,—three simple—hydrogen, carbon and nitrogen—and three compound,—carburetted hydrogen, ammonia and cyanogen—we observe the same sort of progression as that noticed in page 85, where the radius, diameter, semi-circumference and whole circumference of a circle are reconstructed by the aid of a self-suggested development of numbers, which were themselves derived from our chain of circles.

The two points which are the termini of the circular radius are represented by hydrogen 1 and carbon 6. The radius line itself is represented by carburetted hydrogen 7.

The line of the diameter 1, 6, 7, is represented by nitrogen 14.

The complete quadrant by ammonia $(1+2)+14=17$.

The complete semi-circle or whole circle by cyanogen $1\ (2+4)+14=(2+1+4+7)+6=20$.

Let us now proceed to the consideration of Oxygen, which, according to our chemical hypothesis, must have been a later development in the same region, than hydrogen, carbon, or nitrogen.

Its specific gravity when compared with hydrogen is 16. Its *penultimate* molecule, (as regards the analysis of atmospheric air), is 4. Both these numbers are defined in the circle; and together they constitute the sum total of its cyphers. We therefore discover a new apportionment of the terms of quantity expressed by all the cyphers in the circle. 4 stands by itself at the lower pole, as the denominator of the specific quantity of atoms which constitute each particle of oxygen. $2+1+6+7=16$ represent the specific gravity of this substance in relation to hydrogen, and the inferred contraction of the volumes of its ultimate atoms.

Again, as to its composition with hydrogen, carbon, and nitrogen, we have water, carbonic oxyde, and atmospheric air as their most equalised combinations. Arranging them in accordance with our method, the most simply harmonious of these three would be the corpuscule of atmospheric air, because it seems to be the result of a union between two penultimate particles; but if they are to be arranged in accordance with the relative seniority of the development assumed in our hypothesis, our attention would be first directed to water.

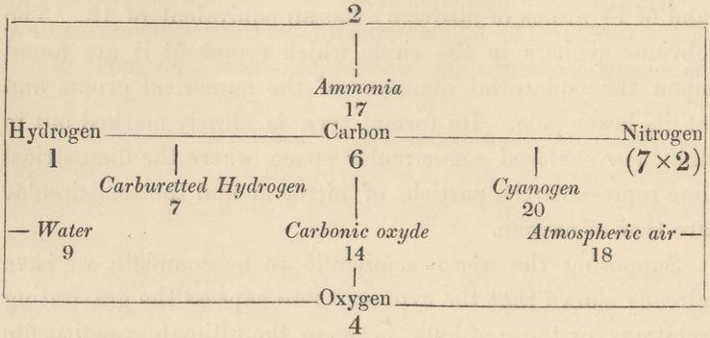
It is however probable that wherever the particle of oxygen is combined in a double proportion with one particle of any other substance, as in all those where oxygen and nitrogen are concerned, always excepting atmospheric air, it belongs to a more advanced stage of development.

Atmospheric air, (each corpuscule of which is generally supposed to be composed of 4 atoms or 1 particle of oxygen, and of 14 atoms of nitrogen), has an equivalent of 18. The obvious cyphers in the circle which represent it are found upon the equatorial diameter of the numerical group, and at its lower pole. Its formal type is clearly marked out in the *lower* enclosed semicircular space, where the diametrical line represents the particle of nitrogen and the semicircular arc that of oxygen.

Supposing the *upper* semicircle to be complete, we have already shown that the cyphers there express the gravitating relations, or those of bulk, between the ultimate constituents of oxygen and hydrogen.

It also appears that water is *formally* typified by the upper *quadrant* on the side of hydrogen in the circle, $1+2+6=9$,—air by the lower semicircle $(1+6+7)+4=18$,—and carbonic oxyde either by the circumference, excluding its centre, $2+1+4+7=14$,—or by the arc between 2 and 4 as the *formal* type of the carbon in the combination, while the radius between 4 and the centre of the circle, doubled by the power of 2 is that of the oxygen.

The following rectilinear arrangement of all the substances noticed in this section, has been framed upon the numerical basis alone. The position of the four simple bodies is given as if the diagram were circular with the corresponding cyphers inserted under the name of each substance. The number 2, it may be remarked, has no physical representative in the diagram, but it is supposed to influence the location of nitrogen (14 representing 7), and to double 4 in relation both to water and carbonic oxyde. There may be some doubt as to the propriety of inserting ammonia, carbonic oxyde, and water in the category, because more than a single particle of one of the constituents is engaged in the combination; but in all the other instances the position is accurate, and the whole diagram is in perfect harmony with the principles already enuntiated.



SECTION IV.

On the various combinations of Nitrogen and Oxygen, in relation to the second *circle of numbers in the series.*

THE most complete realisation of the second numerical circle is found in the known combinations of *oxygen* and *nitrogen.* The various proportions in which they are combined, are in perfect harmony with the cyphers contained in the second group of our numerical chain, supposing that atmospheric air belongs to the first group, and that nitrogen itself, which combines in a constant quantity with the several proportions of oxygen, is also represented there instead of in the second.

Let us consider the complementary cypher 8, as the *multiplicand*, and all the other cyphers as *multipliers* of 8. This rule seems to be suggested by the progression of 2×4=8, which demonstrates how the idea of 8 is attained, supposing the central 4 to be the type of the particle of oxgen, and 8 to represent two such particles, when influenced by the power of duplication which is thus made manifest in the cypher 2.

Then 8×2, will be the terms of the *four* particles of oxygen, which when added to one particle of nitrogen, 14, will be the first of these secondary combinations; and it will denote *nitrous oxyde*, whose equivalent will be O 16+N 14=30 ultimate atoms. The following series will thus be made manifest in accordance with the cyphers of the second group of the chain.

	Oxygen.		Nitrogen.		
Nitrous oxyde	8 × 2	+	14	=	30
Hyponitrous acid	8 × 3	+	14	=	38
Nitrous acid	8 × 4	+	14	=	46
Nitric acid	8 × 5	+	14	=	54

When these proportions of the various combinations are arranged in their relative positions in the circle, they will appear in the following order.

	3 Hyponitrous acid O 24+N 14=38	
2 Nitrous oxyde. O 16+N 14=30	4 Nitrous acid. O 32+N 14=46	8 Multiplicand. O 4×2=8
	5 Nitric acid. O 40+N 14=54	

In this instance we observe the cypher 8, holding the same abstract arithmetical relation to the other cyphers of the second group, as that of 2 to the other four cyphers of the first group. In both cases we find that four distinct substances are arranged in a semicircle, but the two semicircles are in *reversed* positions, and if they were placed within the same area, their diametrical lines would be at right angles to each other.

If, however, we substitute 18 for 8 in the second circle of numbers, supposing that number to represent the corresponding semicircular arc in the first circle, in which 7 occupies the position of 8 in the second,—and that 18 be accounted for by the process $4+(7\times2)=18$,—we shall have placed the equivalent of atmospheric air in the same group with all the other binary compounds of nitrogen and oxygen. This method of combining cyphers and of substituting the total for some other original number in a group, has been already demonstrated in the preceding essay. (See page 55.) In the present instance the harmony resulting from the process is extended to the physical parallelism: on previous occasions the operation only had reference to formal and numerical coincidences, in the abstract.

Supposing 18 to be the substitute for 8 here, and the other cyphers to be unchanged in the second group, they will represent a complete semicircular arc and a diameter, while 18 will typify the line of a semicircular arc, without its diameter. The *formal* result however will be a complete circle, in which 18 will really represent the equivalent of atmospheric air, while the other numbers will be logarithmic powers, or *indices* of the quantity of oxygen particles in all other compounds of nitrogen and oxygen except atmospheric air. This arrangement, therefore, although in itself a most harmonious combination, is less complete than the other, in which 8 represents the equivalent of the double-particle of oxygen, or the form under which it combines with nitrogen under the influence of the other numbers of the circle. The following scheme would suggest the idea of an entirely new group, supposing the equivalents of the four substances were expressed in full by 30, 38, 46, 54, as atmospheric air is by 18.

	$O\,(8\times3)+N\,14=38$.	
	Hyponitrous Acid.	
$O(8\times2)+N\,14=30$.	$O\,(8\times4)+N14=46$.	$O4+N14=18$.
Nitrous Oxyde.	Nitrous Acid.	Atmospher. Air.
	$O\,(8\times5)+N\,14=54$.	
	Nitric Acid.	

But, as it seems more reasonable to suppose that the earliest mode of combination of nitrogen and oxygen was in the corpuscule of atmospheric air, because in all other known instances of their binary compounds the particle of oxygen is double,—we are warranted in the assumption, that the second numerical group in our original chain, where 8 is a complementary number, was the *model* category. It is only one of the necessary coincidences of the entire scheme, that if 18 be considered the substitute for 8, it should represent the equivalent of the most simple combination of oxygen and nitrogen, the formal model of which is also to be found in the first group of numbers. That this should be so, is very wonderful, but not more surprising than that 8 should be the basis *multiplicand* in reference to every number in the second group, when referred to the proportions between nitrogen and oxygen in all binary combinations except air,—or than that 7 should have an exactly similar position in the first group, where it holds the same relation of a multiplicand in reference to nitrogen, as 8 does in the second group in regard to oxygen.

We may discover a very perfect harmony in the more artificial combination of cyphers, supposing the equivalents of nitrous oxyde, and the hyponitrous, nitrous, and nitric acids, be the substitutes for 2, 3, 4, 5 in the second group, although the harmony will be interfered with by the substitution of 18 for 8. This is an additional reason for separating atmospheric air from the other compounds. It will be found, that if we add together all the equivalents of the combinations of oxygen and nitrogen, which are represented in the second numerical group, we have the following general sum $30+38+46+54=168$, in which the equivalents of the oxygen are exactly twice those of the nitrogen, for $112+56=168$. The admirable harmony of these relations is still further exemplified in the fact, that $56=14\times4$, which is the *multiplying* method of arranging the $14+4$, the joint equivalents of atmospheric air. Moreover, the quantity of *oxygen* atoms in the general category may be represented as $14\times8=112$, which is the double of those of the nitrogen atoms 14×4; thus the new basis 8 is multiplied by the precise quantity of ultimate atoms, which are assumed to constitute a specific particle of nitrogen.

Still farther, the quantity of *nitrogen* atoms in the general category of nitrous oxyde, hyponitrous acid, nitrous acid and nitric acid, is the basis equivalent of the nitrogen particle, multiplied by the equivalent of the oxygen particle, $14\times4=56$.

When we advance beyond this plan of harmonizing the equivalents of oxygen and nitrogen, and consider *both* numerical circles, and the equivalents of the chemical substances, which have been referred to them, *as one system*,—we find that as regards the first circle, the total was 110; 25 representing the equivalents of the simple substances, and 85 those of the lowest binary compounds. Now if we subtract that total 110 from 168, the remainder will be 58, or $50+8$. In this case each cypher of the two circles will give 5, because 25 or 5^2 was the representative value of the number of cyphers in the first circle, and $50=5^2\times2$. The number 8 represents the quantity of cyphers, whose places will have been occupied by the four simple substances in the first group of cyphers, and the four compounds of oxygen and nitrogen in the second, while the first and last cyphers 2 and 8 are treated as symbols or powers of duplication and relation.

Secondly, if 110 be subtracted from 112, we have a remainder of 2, the first arithmetical term of the chain.

Thirdly, if 168 be divided by 4, the equivalent of each particle of oxygen, and the central cypher of the second group, (in which case it is the basis type of all the combinations in question between oxygen and nitrogen), the product will be 42, the exact arithmetical sum represented by the cyphers of both groups without reference to physics or chemistry.

In every instance, therefore, do we discover the development of perfect harmony, when we represent the cyphers of the abstract system by particles or corpuscules of the simple substances in question, or their binary compounds; and we are irresistibly led to the conclusion that the numerical laws which control the relations of hydrogen, carbon, nitrogen and oxygen, are to be found in the two first groups of cyphers, which contain the geometrically suggested series of 2, 4, 7, 1, 6, 3, 4, 5, 2, 8.

SECTION V.

General considerations on the application of groups in the chains of cyphered circles, to chemistry.

THE object of the present essay is only to explain the method of applying the arithmetical scheme suggested in the preceding treatise, to the author's physical hypothesis, which accounts for the transmutation of ultimate atoms, and for the gradual development of all chemical bodies.

Attempts to enlarge upon specialities, would lead to a series of details, which might be extended until this essay became much longer than the treatise on numbers. He now contents himself with having demonstrated, that there is a complete harmony between the incontestible certainties of the geometrically-derived arithmetical system (in itself a perfect scheme of progressive development), and the universally-admitted doctrines of modern chemists about definite equivalents; and with having shown that such a concordance is a corroboration of the great probability, that *every* process in Nature is one of a general system of graduated and automatic development, not only with respect to the organic, but the inorganic world.

The labour of applying the abstract system of our geometrically-derived ideas of form and number to chemistry, requires the aid of many observers of Nature in that department alone: but any joint analytical endeavour to verify the general proposition with respect to the known phenomena of other branches of physical science, would be ineffectual, however devoted chemists might be to the undertaking, unless they were assisted by astronomers, botanists, and zoologists. Still, the chemical application of the proposition is by far the most important, because chemical science holds the same rank in the great but limited realm of Nature in reference to first principles, as that of arithmetic itself in the all-containing Universe of the ideal world.

It should be borne in mind, that although in the preceding essay, three mutually-dependent chains of cyphered circles have been deduced from the original geometrical series arranged in the two circles to which constant reference has been made in this,—there is no limit to the variety of chains, which may be constructed upon the same basis. It is probable, that as regards the vast laboratory of Nature, the number of such chains is immense. Some of them may be suggested by chemical phenomena; others by harmonies in acoustics, and by the practical discoveries of musical composers, whose instinct has suggested many charming novelties, which the mere theoretical student might have never thought of; and others by as yet unknown phenomena in optics. In all cases, however, we may rest assured that one great and general scheme of abstract numbers presides over every practical combination of chemical substances, of colours, and of sounds.

It is affirmed, that the famous Pythagorean phrase "of the *music* of the spheres," meant one universal harmony *in the abstract*, in obedience to which the whole system of Nature has been, is, and will be made manifest. We may conjecture, that all the phenomena appreciable by ourselves, are as nothing when compared with those which are now being developed in boundless space. Yet this conviction of our own incapacity should not deter reasonable minds from the boldest attempts to generalise, or from endeavouring to discover the elementary principles of that harmony, which must pervade the moral and physical universe.

The *formal* arrangement of atoms, and of their distinct molecular aggregates, is one of the most interesting branches of the general inquiry, since it immediately connects the abstract laws of geometry and arithmetic with their physical application to the phenomena of electro-chemistry; but previously to entering upon this investigation, we should ponder deeply upon the elastic and cohesive conditions of bodies. In any attempt to discover the formal relations of dissimilar particles, which constitute a compound chemical corpuscule, or, indeed, of those which are the constituents of any simple body, we must reduce them by inference, at least, to the gaseous state; but, even then, the difficulties of the investigation are more serious than might have been expected by the analyst, in whose method of calculation there is no allowance made for the various *ratios* of expansibility special to different sorts of gaseous substances. We cannot admit that the same given amount of atmospheric pressure should affect all gases according to the same ratio; for, although it may be surmised that there is a *zero* point, at which elasticity ceases, common to all gaseous bodies, the analogy of the freezing and boiling points of a thermometric scale being different for most substances, suggests that in a state of gas they would not expand in the same ratio during their gradual liberation from that external pressure which promotes their elasticity.

When a gas becomes liquid under pressure, we may infer that the great elasticity peculiar to that condition of a subtance, is nullified and rendered *latent;* on the other hand, when the liquid is vaporized, the latent force of its elasticity is liberated from the operation of some peculiar law, which determines that that force should have been altogether restrained in the liquid state. Therefore,—since it is probable that heat may be attributed to *pressure* in every case, when we search for its *ultimate cause*,—we arrive at the conclusion that the two sorts of pressure (the one internal, which is *specific* and *normal* to every distinct sort of substance, supposing there be no external pressure,—the other external and depending upon external compression), may be the results of antagonistic forces. This would also explain why, when the *internal* pressure passes a certain limit (as regards the point of vaporization), in relation to the *external* pressure, a fluid substance is liberated from the influence of the law which had previously rendered its elementary elasticity *latent*, and had promoted its condensation in a liquid state.

It follows, from this method of reasoning, that the internal *normal* heat of any substance, when it is perfectly free from the external pressure occasioned by centripetal gravitation, may always maintain it in a gaseous state; also, that external pressure alone is the cause both of liquidity and solidity, and that every body would be at the *zero* point of its gaseous expansibility if there were no other pressure than that depending upon a resistance of the non-atomic ethereal medium to the intrusion of the atomic void. (*c*)

Such considerations are of great moment to the analyst, when he is engaged in the endeavour to determine the relative weights and bulks of different sorts of gaseous bodies, because he may infer that when different gases are compressed, the same amount of atmospheric pressure would occasion very different *expansible* results, even in simple substances. In one substance, it may have indicated the point in the scale at which the fluid, or even the solid condition of the body has been promoted; while in another, it may not be near the limit where such a sudden change has been effected as that of the conversion of a gas into a liquid—an operation,

(*c*) This opinion about the cause of the normal or specific heat of each body being in proportion to the space which is occupied *absolutely* by its ultimate atomic constituents, has been already explained more fully in the fourth section of the second essay, page xciv.

as has been assumed, which, to a great extent, nullifies the normal *internally-derived* pressure of each envelope of a molecule, or renders it *latent.*

The only *normal* condition of a body, according to this method of accounting for the *specific* heat of bodies, and for the presence of heat occasioned by atmospheric or any other sort of pressure, would suppose the absence of *all* external pressure, except that of the space-pervading ether.

But it is a question of paramount importance in the inquiry, to determine *what* is compressed. The whole argument suggests that the internal or primary atomic individual is incapable of undergoing any other formal change than that which is gradually consequent on the diminution of its polar and the increase of its equatorial diameters, which joint process of secular alteration in its form has been already accounted for. That the absolute substance of the atomic shell should be compressible, cannot be admitted, if we adhere to the speculation already advanced in the preceding essay about the generation of the atom.

Two opinions have been long entertained in reference to the cause of gaseous elasticity, which are decidedly opposed to each other. According to one, molecules are never in contact when in a gaseous state, and when the greater or less distance between them is occasioned by the varying intensity of their mutual repulsive energies. According to the other, the elastic force is a result of the compression of each molecule, which depends upon peculiar chemical laws proper to each substance, for its modification in relation to the same amount of pressure. If we adopt the second of these hypotheses, and adhere to the supposition that every distinct molecule is coated by a sort of ethereal atmosphere, segregated by its own electric influence from the surrounding non-atomic medium,—we shall find that the internal nucleus may remain unchanged in bulk and shape, while this layer or envelope may undergo a compression sufficient to account for all the phenomena of gaseous elasticity, and that it may be either expanded by the application of artificially or naturally promoted heat, or so compressed by artificial or natural mechanical means, as to make it pass that limit, beyond which its elasticity becomes *latent.* This doctrine will also account for the inferred chemical changes of the natures of simple substances,—in other words, for that absolute transmutation of chemical bodies, which we have already supposed must be the evitable consequence of a gradual alteration in the form and bulk of each ultimate atom.

No observable magnetic phenomena will determine the size or form of such an envelope, although they may suggest the basis idea of its real existence, and of its development being contemporaneous with that of the molecule which it surrounds. If we assume, that *because* the weight of an ultimate atom remains unchanged, however its form may be altered, the quantity of its material substance will be the same throughout the whole period of its individual existence as a distinctly separated portion of the ether which pervades space,—we may apply the same conclusion to a *secondary* portion of substance congenitally separated by the atom's contingent electrical currents from the substantial medium which surrounds it. But, in that case, the atom and its envelope would have different attributes; experiments have proved that when one electric current generates another, they do not resemble each other in their physical or physiological effects ; and these two different shells of material substance (one within the other) would constitute a sort of compound aggregate, which might be expected to develope some phenomena analogous to those of centripetal gravitation.

If the internal nucleus be incompressible, it would not be exposed to any force capable of interfering with its existing form, except that which results from the secular approximation of its own poles, a change necessary to the basis-hypothesis of its generation. It has been already suggested that the ethereal medium in its neighbourhood would undergo a compression proportioned to the space occupied by the atom; but if we imagine a distinct layer of the ethereal substance to intervene between the atom and the medium beyond, such an atmosphere being congenitally separated from the mass in a fixed quantity—and we admit that this envelope is compressible—the surrounding medium would press equally upon all parts of the envelope, and compel it to assume the *spherical form*, whatever might be the shape of the internal atom. Unless the incompressible nucleus were a sphere, the depth of its envelope (under such an hypothesis) would be unequal upon its different circles of latitude; if the atom were an extremely oblong spheroid, it might be an almost rectilinear diameter of the spherical envelope. But, as the form of the atom changes, there must either be a gradual alteration in the pressure, or of the distribution of the substance of the envelope over its surface; and if the quantity of that substance were still unchanged, and the external pressure of the medium beyond remained the same, while it enforced the spherical outline of the form of the envelope, and maintained its bulk such as it was at first, —it is evident that while the atom itself was gradually expanding from an oblong spheroid into a sphere, its increase in volume would act upon the envelope as an increasing compressing force, and that the pressure would be at its greatest when the internal nucleus was a perfect sphere. (*d*)

But, if such be the general conditions of the process, the period must arrive when the internal nucleus will so change

(*d*) This idea harmonizes with the suggestion already advanced, that hydrogen is composed of molecules, which are spherical, heat being admitted to be one of the consequences of pressure, since the specific heat of hydrogen exceeds that of any known substance. It also suggests that all the pressure occasioned by the existence of atoms may be limited to their envelopes; from which it would follow that the general mass of the ethereal medium surrounding a body may not be at all compressed, and that there is no heat in the spaces between the sun and his planets. A contrary supposition has been advanced by the author in the fourth section of the second essay, where no allowance is made for the variable and distinctive characters of an atom's envelope.

its form, that its equatorial diameter will be extended to the original outline of its envelope. This must happen *after* the atom itself has undergone the conversion of its own spherical outline into that of an oblate spheroid, but not immediately; for it has been already proved that the *original* distance between its poles, which is the constant diameter of the envelope, is longer than the diameter of the atom would be at the period of its conversion into a sphere, by the difference between those of the circles F K L H and W *h* V *e*, in plate 4. If we suppose these two circles to be concentric, and the *original* poles of the atom and of its envelope to be at the same points, —the diagram would then demonstrate the spacial relations of the spherical atom and its envelope, when they jointly contribute to the apparent bulk of a spherical molecule.

Supposing the elasticity of the envelope to be at its *maximum* at that moment, and that its own spherical outline undergoes no change, the calorific hypothesis would lead to the inference that the greatest *specific* heat of each molecule would be developed under such conditions. But the elasticity would gradually diminish as the internal poles H and V converged to the common centre Z, and the two ends of its equatorial diameter increased their divergence from Z beyond *h* and *e*, until they reached the spherical outline of the envelope upon its equator: this would occur at the moment of the original poles of the atom reaching the point Z, which has been supposed in the general scheme to be the period of the evanescence of the internal nucleus, and, consequently, of that of the envelope, whose individuality (in relation to the medium beyond) depended upon the secondary electric currents, which were promoted by the aboriginal or primary activity occasioned by the reciprocity of the opposite poles in the internal atom itself.

Thus the purely geometrical scheme, as regards the harmony between the ellipse and the circle, accords with the physical hypothesis, so far as the spacial changes and the electrical influences generating the envelope are concerned. Its dissolution is a physical as well as a mathematical necessity in such a scheme; the event is at once a certain coincidence in the geometrical problem, and a necessarily inferred effect in the electrical process.

Let us now proceed to the generalisation of this surmise about the form and elastic nature of the envelope, by applying it to the *penultimate particles* in a simple chemical substance, each of which is supposed to be an aggregate of a limited number of ultimate atoms,—and to the corpuscules of a compound substance, which are generally believed to be also individually composed of a fixed quantity of *dissimilar* particles. The laws of cohesion are intimately concerned in this application of the hypothesis, which accounts for the specific heat, or compressed condition of the envelope's substance.

Polarization, as the fundamental process of Nature in her realization of geometrical forms, pervades every electrical system. In our scheme, this principle is reduced to its first conceivable elements; the generation, maintenance, and dissolution of the ultimate atom are supposed to depend on it, and its prevalence is assumed in all that regards the envelope of every distinct material molecule. The separate atom, the simple particle, the compound corpuscule, and every sort of simple or compound body which they constitute, supposing the congeries to have its own distinct outline, must be in the same condition of envelopment by a layer of non-atomic matter, which intervenes between itself and the general ethereal medium, and which is distinguished from that medium by being under the influence of secondary polar currents generated by the internal atom, or any individualised combination of atoms. Every heavenly body indued with astronomical locomotion, ought, according to the hypothesis, to be thus circumstanced.

But the peculiar electrical or magnetic properties of the envelope must depend upon the comparative simplicity or complexity of the nucleus, and it has been already shown that *the intensity of cohesion diminishes in proportion to the complication of the nucleus,*—until it ceases to exist in astronomical cases, where there are regular alternations of attraction and repulsion, the one force replacing the other as soon as either of them has attained the limit of its influence.

It is also a justifiable inference deduced from analytical experiment, that the *ultimate* atoms which constitute the same chemical particle of a simple substance, cohere with a greater intensity than that which maintains the union of *penultimate* particles in the same compound corpuscule.

Now, our geometrical conditions suppose that after an insulated atom has attained the spherical form, there is a less depth of envelope at its equator than over its poles; while the physical data would suggest that the substance of the envelope does not so diffuse itself in consequence of this pressure as to move from the equatorial to the polar region, but that the internal pressure acts upon it as if it were an elastic solid, in which case the intensity of the pressure at any point would depend upon the distance between the outer surface of the envelope and the nearest part of the convex surface of the internal nucleus; this would be the consequence of the prevalence of the general law, determining that the amount of pressure at any given point in an elastic substance, should be measurable by the square of the distance from the compressing body. It must also be borne in mind that the existence of the envelope is attributed to interpolar currents of magnetic electricity, they being generated by rotating currents, which are supposed to derive their origin from the aboriginal interpolar currents pervading the whole substance of the nucleus; because this consideration leads to the inference that when the internal nucleus is *oblate,* a greater intensity of the secondary currents of the *envelope* would be transmitted through the confined *equatorial* portion of its substance than through any other region, since the depth of substance would then be less on the atom's equator than over its poles.

Locomotive attraction, moreover, is attributed to the influence of these secondary polar currents, and seems to act either tangentially, or at right-angles to their direction, by reciprocating with interpolar currents in the envelopes of other molecules. The intensity of this attraction may, therefore, not only depend upon the distance between the surfaces of the envelopes, but upon the quantity of the interpolar currents passing over, or through them. Should such be the fact, the cohesive attraction of molecules, whose envelopes are drawn into contact by this influence, may be reasonably attributed to the envelopes themselves having attained some condition which brings the currents nearer to each other over the equator; and the intensity of the cohesion may depend upon the proximity of the surface of the internal atom to that of its envelope.

Pursuing this application of the geometrical hypothesis to the physical problem, we find two opposite stages of the above-imagined intensity of the envelope's polarising currents. When the internal nucleus is oblong, they would be less intense at the equator than near the poles: when the nucleus is oblate, the preponderance would be at the equator. In both cases we might expect that the equatorial and polar regions would have opposite attributes as regards cohesive attraction; but the spherical form of the nucleus is intermediate between these two *formal* opposites; and, by the same mode of reasoning, it may be inferred that some sort of balance between the physical influences in connexion with the polar and equatorial regions, depends upon this equilibrium. Still, it would be a hasty conclusion to assume, that the equilibrium was that of the change of the most attracting intensities from one portion of the envelope's surface to another; for the general review of the whole doctrine in reference to interpolar currents is hostile to the notion, that the poles of an envelope themselves have the power of attracting or repelling, if the secondary longitudinal currents converge to them. The inductive influence, which is made manifest in the phenomena of attraction or repulsion, seems to depend upon reciprocities between the *moving* currents on the surfaces of molecules; and elsewhere, in another portion of the present treatise, the probability that the poles are those points at which interpolar currents converge and terminate, has been already advanced. In the neighbourhood of a molecule's poles, there may be such influential currents, but not at the poles themselves.*(e)*

But the equatorial portion of any insulated molecule or body, is evidently the most important, as regards the influence of attraction, and probably of repulsion. In the ultimate atom, it is supposed to be constantly approaching the surface of the envelope, and although until the atom itself is spherical, there can be no *spacial* equilibrium, the internal pressure of the nucleus upon the equator of its envelope is estimated in the problem as a constantly increasing force, from first to last.

Such being the data in regard to the elasticity and cohesion of molecules, let us meditate upon the condition of the ultimate atom, when it combines with a fixed number of

(*e*) See the *fifth* section of the second essay "On the first conceivable Development of Physical Locomotion," and the *twelfth* section of the same essay "On the Magnetic Influence of the Sun and Moon;" more especially the page ccxi, and those which follow it. The reader must, however, bear in mind that in the experiments on the polarities of needles, there is no such *normal* force of primitive compression acting upon their *envelopes*, as is supposed to occasion the sphericity of those of the insulated atom, penultimate particle, or any other *chemical* molecule. The hypothesis now under consideration supposes that a *body* consisting of several *chemical* molecules, has an envelope of a less constant character than those of its *ultimate* or *penultimate* constituents, each of which is surrounded *evenly*, by the aboriginal *nonatomic* medium. The form of the needle's envelope is most probably that of some continued, but irregular curve, which accommodates itself to the general outline of the nucleus. It may also be inferred, that because the interpolar currents which promote the envelope in this instance, are generated by a *body* of a very compound nature, the envelope itself is *generically* different from those which coat the ultimate atom, the penultimate particle, or the *chemically-individualised* compound corpuscule.

similar atoms, in that sort of molecule which, throughout the present treatise, has been termed a *penultimate* particle. The argument precludes us from supposing that the ultimate atom, whether it be insulated, or in this intimate combination with others, can be deprived of its envelope ; but the phenomena of liquefaction and solidification suggest, that there are certain points in the general scale of compressibility, where *sudden* changes occur which are connected with the *annihilation* of *gaseous elasticity*, notwithstanding a continuous increase of pressure. The extreme point of *expansibility* in this theory, must be that of the incipient state of the atom, when there is no other pressure than that of the general medium, which is supposed to impart a spherical form to its envelope. This primary force is estimated in the problem as a constant quantity, maintaining the original bulk, as well as the form of the envelope, until that great alteration occurs in the condition of the ultimate atom, which is implied in the generation of a distinct molecule, consisting of a fixed number of atoms in intimate cohesion.

Whenever such a combination first takes place, we have grounds for the surmise that the *aboriginal* pressure of the general ethereal medium is transferred by the process ; and that as each ultimate atom in the particle must thenceforward be contained within the *envelope of the particle*, which, according to the general law, would be spherical,—the envelope of each atom would be no longer exposed to the regulating influence of the ethereal medium, which thenceforward bounds the new envelope of the aggregate. The proximate cause of the existence of any such envelope being admitted to be the magnetic currents which are generated on the surface of *any* nucleus, and their evident tendency being to accommodate their own direction to the external form of their generating particle, or corpuscule,—it follows, that when the interference of the aboriginal pressure of the ethereal medium is removed from the envelope *of each atom*, its form and bulk would both depend upon those of the ultimate nucleus itself, and that the controlling influence, as well as the aboriginal pressure of the general medium, would be *transferred* from the envelope of each atom in a particle, to that of the whole particle. Such an hypothesis would account for six *ultimate* carbonic atoms occupying the same space as a single atom of hydrogen, and for the annihilation of all the previous *constant* spacial attributes of each ultimate atom's envelope in the carbon, while those of the ultimate atoms in hydrogen were unchanged.

Thus the same ultimate atom, when aggregated with others in a particle, may suddenly have new attributes. The quantity of space which its envelope occupied previously, may be greatly reduced without any diminution of its weight; the normal elasticity of its envelope may be almost annihilated. During its previous existence as an insulated molecule, that elasticity would have been gradually increasing until the nucleus became a sphere; even after the nucleus began to grow oblate, and the general elasticity was decreasing, there would be a continuous increase of internal pressure on the equatorial portions of the envelope, *unless the moment of the commencement of the atom's oblateness were that of its combination with others in a particle.*

The whole question of cohesion and its cause, must be fully considered in reference to this doubt; for it is evident that the species of cohesion developed in the aggregation of ultimate atoms in the *same penultimate particle*, is more intense than any other. The opinion advanced in the second essay of the present treatise about the nature of *ozone*, supposes that it is the insulated or single atom, and that each such molecule acts upon another, repulsively. This may be that sort of mutual repulsion, which is believed by some chemists to occasion the elasticity of *all* gaseous bodies; but there are reasons for the supposition that it is only applicable to the mutual relations of *oblong* atoms, and that it does not prevail where oblong and oblate atoms affect each other. An entirely distinct class of laws seems to be dominant in relation to *ozone* ; and there may be as many different sorts of this as yet unknown class of substance, as there are of the other class which consists of *aggregates* of oblate bodies. It is possible that the nerves of smelling are peculiarly affected by them, and that each different odour is due to an impression made by single oblong atoms having a form specially intended in reference to physiology, to call into activity those peculiar varieties of sensation by which we distinguish one scent from another. It is also probable, that although *oblong* atoms repel *each other*, they are endued with an elective tendency to attach themselves to *oblate* atoms—in accordance with some general law which determines the mutual appetencies of certain *aggregates* of *oblate* atoms, and of certain forms of the *insulated oblong* atom,—and that they may be liberated from such a combination, and restored to their insulated condition, when simple or compound bodies are broken up either by analysis, or by a mechanical force, should they have so interposed between the layers of particles or corpuscules, that any seemingly homogeneous body was saturated with them, as bodies are known to be by the molecules of others,—atmospheric air with those of water, for instance.

The latest experiments on *ozone*, also suggest, that water has been formed where every care had been taken to prevent the intrusion of hydrogen ; this would imply, that the least oblong molecules of the ozone may have undergone some accelerating process, converting them into the hydrogen, which was necessary to the aqueous compound,—a supposition perfectly in harmony with the hypothesis that the hydrogen stage is the first in the conventional scale of ponderable substances. But the whole subject of ozone has been hitherto so little investigated, that we are checked at the outset of our inquiry into its nature, and its probable varieties and species, in consequence of the deficiency of information afforded by practical chemists.

Still, the assumed mutual repulsion of *oblong* atoms, is not to be confounded with that which is observable in astronomical *dynamics;* the whole argument suggests that it is *statical*, and that it does not promote the regular locomotion which is connected with the orbitual movements of heavenly bodies. Judging from analogy, the category of phenomena under which the relations of oblong atoms should be arranged, are those of chemical elective affinities; and it has been already surmised that in all chemical phenomena, this apparent repulsion is a modification of attraction,—but of attraction under the control of a general law, like that of elasticity. The hypothesis of those chemists, who believe that the molecules of a gas are not in contact, but act upon each other, statically, at certain limited distances, may be only applicable to ozone. Every *oblong* atom which is not attached to a chemical aggregate may be really held in a fixed position by the attraction of another, (supposing a *primal* or normal state of limited distance, and no interference from a third atom), by a force analogous to that of cohesive attraction; the *extreme* possible distance between them, under such conditions, may indicate a decided limit to the force which holds an analogy to the *zero* of elasticity in a gaseous body, and the *normal* distance between *oblong* atoms may gradually diminish, in proportion to the increase of their equatorial diameters, (when compared with the depth of their envelopes), until the envelopes are in contact, when their *nuclei* become spherical. Such a doctrine would harmonize with several other surmises and observations which inculcate as a general principle, that throughout nature there is a *continuous development of the same elementary tendencies;* and it would be a connecting link between our ideas of *centripetal* attraction, elasticity, and cohesion. Ozone is found to be a ponderable substance, and it admits of being compressed.

Should this speculation about the condition of the *oblong* atom be correct, (so far as its relations to atoms having a similar form are concerned), the contact of the spherical envelopes, when the nuclei have attained the form of a sphere, would be an important stage in the progressive development of attractive intensity. But it does not follow that this termination of their *apparent* mutual repulsion must be immediately succeeded by any alteration in the normal or statical distances between the nuclei themselves; the mere fact of cohesion being the result of the envelopes of the nuclei being in contact, might be the cause of the development of a body, or mass of molecules, whose atmospheres were in close contiguity; but the spacial forms of the outlines of the envelopes, and their individual bulks, might not be affected by the simple condition of contact, provided there were no increased *external* pressure. At present, we are investigating the question under such a proviso: the only *external* pressure given in the problem, is that *constant* influence of the surrounding medium, which is supposed to maintain the size and *spherical outline of the envelope* from the commencement of the atom's existence: the pressure which is imagined to increase gradually from that moment until the *nucleus* becomes spherical, is promoted *internally* by that change alone.

We have thus accounted for the gradual increase of the force of mutual attraction, until it promotes simple cohesion: we here find the termination of the stage in which attraction, *at a fixed distance*, has the double semblance of limited repulsion, and limited elasticity. This sort of cohesion, however, although probably the first which is developed in Nature, as regards each individual atom, must be less intense than that which prevails, when the envelopes of atoms are relieved from any *direct* external aboriginal pressure of the ethereal medium, which maintains their sphericity and constancy of size. The general law obviously suggested by the whole argument is, that the more the secondary electric currents agitating the substance around each atom approximate at the equator of the envelope, the more intense will be their attractive force. The spacial equilibrium between the atom and its envelope will have been attained when the internal nucleus is a sphere ; and it is in consistency with all the other elementary laws assumed as *data* in the hypothesis, that the absolute contact of the envelopes, should be always maintained, subsequently, (unless it be interfered with by the chemical processes of nature, or of a laboratory), and that the direction of the secondary interpolar currents should follow the outline of the atom, as soon as its equatorial diameter is longer than that between its poles. It has been already shown that there is no other mode of accounting for the *spacial* changes necessary to the aggregation of a limited number of ultimate atoms in any penultimate particle, which seems to be a more intense condition of attractive cohesion than that which was the first consequence of the contact of spherical envelopes.

Hence, it may be inferred, that if the internal nucleus or atom itself, be spherical in the case of hydrogen, the cohesion of hydrogen molecules is probably of the same order as that which maintains the combination of each special aggregate of other simple substances, where the spherical envelope of the aggregate represents that of the single atom under previous formal conditions. Each such *aggregate*, in carbon, for instance, may cohere with other similar aggregates of carbon, when they constitute any quantity of that substance, with the same tenacity as that which maintains the cohesion of the *ultimate* atoms in the hydrogen. Supposing, also, that the aggregate particle of carbon is surrounded by an envelope, the form of which exactly resembles that of an envelope surrounding the single atomic constituent of hydrogen, the only questions undetermined in reference to the particle of carbon, would be,—the formal mode in which its ultimate atomic constituents are in contact *within the common envelope of the particle*,—and the reason *why* the particle itself should either be broken up, or so combined with others as to become a portion of some other particle ; it seems an inevitable consequence of the secular change of form and bulk of the ultimate atom, that every existing particle must undergo some such process.

Admitting the validity of these speculations about the chemical cohesion of ultimate atoms in the same penultimate particle of a simple chemical substance, we still find that ultimate atoms so combined need not be in *absolute contact ;* their separate envelopes may still exist, and the contact may be between *them ;* but the depth of each envelope may be inconsiderable, and it may gradually diminish as the atom becomes more oblate, so that the contact would bring the internal nuclei nearer each other in heavy, than in light substances, consisting of many similar penultimate particles.

Not only, therefore, does the change of the envelope of the ultimate atom account for a primitive aggregation of atoms in a fixed particle ; it also explains, *why* in every species of simple substance, the aggregate nucleus differs, because its constituents have different relations of contiguity. We must admit, however, that a gradual alteration in the form of the *particle's nucleus* may occur without any change in the external form of its envelope, beyond that of the currents being more compressed by the increasing equatorial diameters of its constituents : the only obvious result of this process would be an increased intensity of cohesion between similar particles, supposing the same general law to prevail in relation to the internal pressure of a particle's nucleus upon the envelope, as that which has been already speculated upon, in regard to the internal pressure of the distinct atom upon its own envelope, in the previous stage of insulation.

But a *general prevalence* of the same law would also suggest, that as soon as the equatorial diameter of the *aggregated nucleus* had expanded, in consequence of the increasing oblateness of each of its constituents, its envelope would be inadequate to the task of maintaining its individuality, and that it would be united to one or many similar aggregates *in the distinct particle of some new and heavier simple substance.* Supposing, for instance, that when the previous change occurred, *three* oblate atoms had been aggregated in a particle, and had undergone cohesion at points upon their equatorial circumferences,—the particle might have an envelope whose equatorial diameter was sufficiently large to admit of a small increase of the general diameter of the nucleus, and the constant external sphere of the envelope might be maintained until that increase had brought the three projecting convexities of the atoms to its extreme surface. It would be in accordance with the above speculation, that the characteristic particle should then cease to exist, and that it should combine in a new aggregate, *which would immediately generate a new envelope.* We are at liberty to suppose that two *ternary* layers of ultimate atoms constitute the nucleus of the carbonic particle, each layer advancing with its three projecting convexities to the surface of the envelope, at equal distances *from* its equator, in each hemisphere; still the assumed result would be the same as if the nucleus were a single layer, gradually intruding *upon* the equator. As the aboriginal magnetic currents, (which, under the previous pressure of the surrounding ether, would have given each insulated atom a spherical envelope), only now diffuse themselves *evenly* over the surface of each constituent of the nucleus—the cohesion of the individual atoms, might thenceforward take place at any point upon their surfaces, with the exception, probably, of their poles.

It must be remembered, that in this *theoretical* argument, it is a *given* condition that there is no *occasional* external pressure of a particle's envelope; we only take into consideration that *normal* compression which is enforced by the surrounding medium. *Practically,* as regards all our experiments and observations, the *occasional pressure* always exists; but the elasticity which it occasions, must not be confounded with the internally-caused pressure consequent on the gradual increase in the oblateness of the constituents of the nucleus. The *external* pressure of the terrestrial atmosphere, for instance, is not considered in the data of the above hypothesis. It is evident, however, that the envelope of a particle is capable of being compressed by an external force, without altering its *specific* character; the gaseous state of the same sort of substance, being exchanged for a fluid, or even for a solid state, is known to be the result of such a compression being increased beyond a certain limit, under which its elasticity suddenly disappears.

According to the general scheme here proposed, *every distinct envelope of a penultimate particle in a simple chemical body* may be treated as the offspring of the *same order* of electric or magnetic currents; but the analogy suggests, that those which give an envelope to a *compound* molecule consisting of *different* species of the simple particle, are less cohesively attractive, but probably endued with higher attributes in the general scale of electrical influences, than those of each simple particle, because they owe their origin to a more complicated source.

It is also to be inferred, that although the envelopes of dissimilar particles thus combined in a corpuscule, (of air or water, for instance), lose their elasticity to a greater extent than would be the result of any external pressure, they regain it when the corpuscule of air or water is reduced, by analysis, to its original *constituent particles*. Hence, in all these secondary, or more complicated processes of chemical aggregation, we meet with the development of elective affinities, requiring temporary suspensions of cohesion, changes of modes of combination, and retrograde processes, which do not occur in the formation of the simple particle, where we have reasons for believing there is no retrogression. But even as regards the envelope of the compound corpuscule, which is subject to so much occasional and varied change, all the *general laws of elasticity* appear to hold the same control. Vaporization, liquefaction, and solidification, may be attributed to the same sorts of interference with the normal condition of the external envelope. Heat may be rendered latent, or it may appear to be suddenly disengaged under similar *general* modifications of pressure, whether the substance be simple or compound. It is not, however, necessary to enlarge upon the question of elasticity, the object of the present digression being to show that even in the development of the most varied chemical phenomena, there are general laws of a geometrical character which must be considered before we can enter satisfactorily upon the study of such phenomena. It would have been premature to attempt the discovery of the *formal* mode in which ultimate atoms and penultimate particles are combined, unless the question of the envelope had been previously reconsidered in relation to the general synthesis. The method of analysis universally adopted by modern chemists, depends upon the accuracy of their measuring the bulks of bodies; and the theory of equivalents cannot repose upon a sure foundation, unless all the effects of pressure are taken into the account.

No notice of the *spherical* appropriation of the cyphered circles to chemistry, has been suggested in the present essay, although, in the preceding treatise on numbers in the abstract, the *superficial circles* have been partially considered under the conditions of that conversion. It is obvious, that this process must be examined, when the formal relations of ultimate and penultimate chemical molecules are the objects of our investigation. The harmony demonstrated by such a method will not only apply to the *quantities* of molecules combined, but to the supposition that every molecule may be represented by a *differently cyphered sphere or spheroid,* although as regards bulk or form it may resemble others with which it is combined. Remarks upon this most marvellous coincidence

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must be reserved for another essay. Enough has been already advanced here, to support the general proposition, that the popular atomic theory harmonizes with a geometrically-derived numerical series, which was first suggested by the undeniable prevalence of definite numbers in the *organic* world,—and with the outlines of a physical hypothesis accounting for the development of every distinct *inorganic* entity, be it an ultimate atom, or a body as vast as that of the solar system itself.

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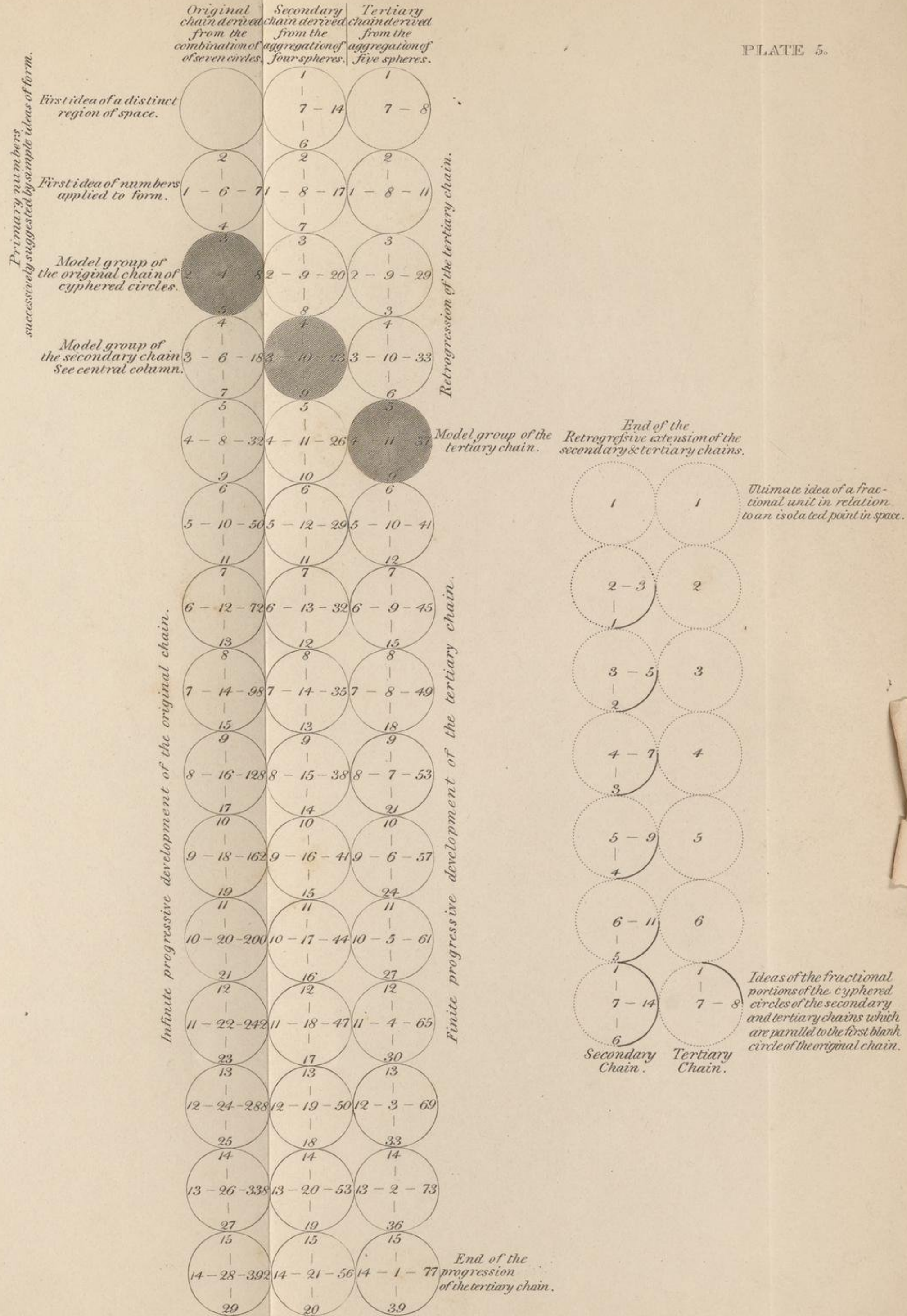
PLATE 5.


Original chain derived from the combination of of seven circles.
Secondary chain derived from the aggregation of four spheres.
Tertiary chain derived from the aggregation of five spheres.
Primary numbers successively suggested by simple ideas of form.
First idea of a distinct region of space.
First idea of numbers applied to form.
Model group of the original chain of cyphered circles.
Model group of the secondary chain See central column.
Model group of the tertiary chain.
Retrogression of the tertiary chain.
Infinite progressive development of the original chain.
Finite progressive development of the tertiary chain.
End of the progression of the tertiary chain.
End of the Retrogressive extension of the secondary & tertiary chains.
Ultimate idea of a fractional unit in relation to an isolated point in space.
Ideas of the fractional portions of the cyphered circles of the secondary and tertiary chains which are parallel to the first blank circle of the original chain.
Secondary Chain.
Tertiary Chain.

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