ÆTHER:

A THEORY OF THE NATURE OF ÆTHER AND OF ITS PLACE IN THE UNIVERSE.

BY HUGH WOODS,

M.D., M.A.O., B.CH., B.A., D.P.H.


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A

PREFACE.

Some seven or eight years ago the Author of this little book, in a pamphlet of about ten pages, called attention to the probability that æther might be a fluid of a nature resembling what are known as gases, and that many of the most important and little understood phenomena of Nature might be capable of much clearer interpretation, if regarded as arising from the various movements and vibrations or pulses of which such a fluid would undoubtedly serve as a vehicle if it really existed. Since then the existence of æther has become more and more accepted by scientific observers. In fact, the only way in which its existence can well be disputed is by imagining the possibility of the existence of motion as apart from a moving thing. Such abstract and immaterial interpretations of natural phenomena are repugnant alike to experience and to common sense, and commend themselves only to those whose thoughts by long study have acquired the faculty of dwelling on qualities of matter apart from matter, and to those who blindly follow a learned leader without attempting to understand the reasons on which he bases his theories.

This little book is a somewhat extended exposition of the theory broached in the pamphlet mentioned above. It can be understood by anyone with a sound elementary knowledge of physics and chemistry, and with a smattering of astronomy. The results following from the effects of difference of momentum in different parts of a fluid, and many other problems, have been inferred from analogy rather than established mathematically. Mathematical proof is, of course, more certain, so far as it goes; but any little error in the facts assumed as the basis on which mathematical deductions are founded vitiates the conclusions. The best ultimate test of any theory is the accuracy with which it accounts reasonably for facts actually observed; and even though this little work may fail to prove the theory which it outlines, yet the author is firmly convinced that a searching comparison of the recognised laws and facts of physics, chemistry and astronomy will be found to harmonise with the deductions which follow from the present theory, or at all events from its general principles.

HUGH WOODS.

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CHAPTER I.

INTRODUCTION.

The Manifestatoins and Functions of Æther.—With all the great advances in our knowledge of the laws which govern the phenomena of the Universe, there has, nevertheless, been but little effort made to discover the real moving causes of these phenomena.

We have got so far as to say that heat, light, &c., are "modes of motion," and capable of being changed into other forms of energy; but, still, one may, without hope of an answer, propound the questions—What is heat? What is light?

Again, we know pretty well the laws of gravitation; but after all, what is gravitation? Why does an apple fall to the ground? We say that the heavenly bodies "attract" one another. We cover our ignorance, as usual, by a name. General experience teaches us, however, that if one body influences another, not in contact with it, this is done by first influencing something which intervenes. The heavenly bodies do not, indeed, pull one another with ropes, or by any other visible means; but that fact does not destroy the great probability that there is some intervening medium through which they do transmit their influence one upon the other; and that there is some mechanical cause for their rotation on their own axes, and for all their movements. The strange phenomena met with in the study of chemistry, when two substances unite firmly together in such a way as to produce a third substance differing altogether from either of them, are now passed over by the use of such terms as "chemical affinity," or are attributed to some kind of electrical attraction, or simply treated as unexplained and inexplicable.

Electricity and magnetism, similarly, are names for we known not what.

While it is, no doubt, idle to expect that, even in the lapse of ages, man will ever be able to do more than interpret, more and more correctly, the impressions made upon his various senses, and appreciate, more and more exactly, the origin and relations of such impressions; yet it does seem that the time has come when, with our present greatly increased scientific knowledge, we might profitably review afresh the foundations on which the various sciences are built, in order to see whether we cannot sink those foundations deeper than they were before scientific knowledge had attained its present height.

Therefore, conscious as I am of the fact that any attempt to fathom the principles underlying the ordinary phenomena of the universe is, *prima facie*, regarded as indicative of a day-dreamer, who fails to appreciate the lines by which all useful scientific researches must be guided; nevertheless, I venture to make a feeble, and it may be a futile, effort to grope after a theory which may carry us a little deeper in our understanding of the ordinary phenomena of the Universe, exhibit a clearer connection between phenomena, which apparently have little in common, and place the elementary facts of several sciences on a simpler and more rational basis.

The whole of space as far as it comes within our ken, is, we may believe, filled with a fluid which we have reason to suppose permeates all bodies whether solid, liquid, or gaseous, though with varying facility and under varying conditions. This fluid is commonly known as "Æther"; but has nothing in common with ethyl oxide except the name. In the æther float the sun, the earth, and the rest of the heavenly bodies, which are known to us. They are completely immersed in it, and soaked through with it.

The solar system, as astronomers tell us, appears to be moving through space, borne along, we may reasonably suppose, in an enormous volume of swiftly-flowing æther.

Now, the resistance offered to the free flow of the æther by the partially impervious bodies floating in it is evidently greatest in the line of the greatest thickness of each body, and less as the thickness becomes diminished. Accordingly, a difference of momentum is thereby caused in the mass of æther, dashing against the body, and there results a current in the æther from places of higher momentum to places where the momentum is lower, with the effect that a whirl, such as occurs in the air under similar circumstances, is produced. These whirls, then, by their continual action, make the bodies more or less spherical, and set them rotating, each on its largest axis, while the whirls, spreading out in ever widening circles, influence the movements of other bodies floating in the same medium. Smaller bodies, which come into the close proximity of such a whirl, are drawn centripetally towards the centre of the solid spherical body, that is, towards the centre of the whirl. Larger bodies, at a sufficient distance, caught in the whirl, are not sucked into the centre, but are borne around the larger body, at the same time rotating on their own axes, and generating their own whirls which are superposed upon the larger ones. In this way, the movements and mutual influence of the heavenly bodies may be explained, in a perfectly rational manner, and without imagining any occult power of attraction. Moreover, the theory, outlined above, affords an explanation of the nature of the "force of gravity," as displayed in the falling of an apple to the ground, which will be dealt with in the next chapter. When the whirl is greater, owing to the larger size of a heavenly body, the consequent centripetal force also becomes greater. The powerful whirl, which goes out from the sun, thus predominates greatly over the other weaker whirls and serves to carry around the sun all the various planets, with a force depending on their distance from the sun and on their bulk, the latter being the main factor which determines the strength of the whirls which they themselves originate.

The æther, in addition to these larger whirls and streams, of which we have been speaking, is capable, as one would expect, of various forms of vibration, as well as actual movement in space. The vibrations of the æther, it is, that give rise to the phenomena of heat, and of light, and to some of those of electricity.

Now, to support the theory outlined above, which supposes that æther flows through space in a mighty, immeasurable torrent, with whirls and vibrations within it, we must consider how, and to what extent, matter offers a resistance to the flow of æther, and the degree to which matter is permeated by æther.

Æther, I take it, is a fluid whose ultimate particles, or atoms, are so small that they pass into the minute crevices or spaces in the most solid bodies. Since a thing becomes indivisible when there is nothing existent so small, or so fine, as to be capable of entering into it, so as to cause separation of two or more portions of it, there seems to be good reason for supposing that matter has a limit of sub-division ending at the point where the particle of æther, which is, perhaps, the smallest in existence, becomes unable any longer to enter into its substance, and divide it into two. Thus, without imagining anything so inconceivable as absolute indivisibility, we obtain a plausible explanation of the nature of the "chemical atom," which can, in accordance with this hypothesis, be defined as "a portion of matter so small that it is not entered, or permeated by, æther, or any other existent agent." If this be an atom, what then is a molecule? The following analogy serves best to explain my view on the subject: It is well known that when two or more smooth plates are brought into close contact in the air, they adhere powerfully although there is in fact still just a little air between them, and the same thing occurs even in a vacuum. In like manner, as it seems to me, two or more atoms floating in æther, and coming into close contact, tend to adhere in a similar manner, forming a molecule, with a little æther still intervening between the constituent atoms. The instances in which so-called molecules are believed to consist of single atoms only, can obviously be explained by supposing their shape to be such as to preclude cohesion of this kind. On the amount of æther intervening between the constituent atoms of a molecule, the stability of the molecule no doubt depends, the shape of atoms, of course, largely determining this. Such molecules, when they float about in the æther, and move freely amongst one another, with a considerable amount of æther intervening, and without any lasting adhesion to one another, constitute what is known as "gas." When the æther intervening between the molecules becomes relatively less, and the molecules, although still moving without difficulty together, are in constant contact, the molecules form conglomerations of a variable character, and gradually a "liquid" results. Continued crowding together of molecules, and consequent exclusion of æther, with greater and greater clogging of the motion of the molecules ultimately results in the formation of a "solid." In a perfect solid the particles, while not subjected to displacing force, have become motionless, and occupy fixed positions in relation to one another. The shape, and other characters of the molecules, of course influence the point at which retardation or stoppage of movements occurs.

It is generally admitted that heat consists in certain vibrations of the æther, and vibrations in the æther evidently tend to keep the particles of matter moving, and to separate them one from another. It is, therefore, easy to understand the effect of heat in bringing about liquefaction, or, when the vibrations are sufficiently increased, the change into gas; and finally, a complete dissociation of the constituent atoms. Cold, on the other hand, or the want of heat vibrations in the æther, has the reverse effect of bringing the particles of matter to rest. Heat by separating the particles tends to diminish the density of a substance, and cold to increase its density by allowing a closer approximation of the material particles. Electricity produces another form of movement, as well as vibrations of the æther, in its active manifestations, and it also tends to dissociate the adherent atoms of a chemical compound.

It follows directly from the view that certain ultimate particles, or atoms, are impervious to æther, that most important modifications must be produced as regards the vibrations possible in portions of æther enclosed within aggregations of particles impervious to it. We should, for instance, naturally expect, from considerations of analogy, that æther, according to the nature and dimensions of the spaces in which it is enclosed, would take up only certain vibrations, stopping, or modifying, others, as the case might be. The phenomena of heat, light and electricity are quite in accord with this, for we find some substances readily transmitting the vibrations of light while refusing to transmit those of heat, and so on; and, similarly, substances that are opaque to light transmit the vibrations of heat readily. The effect on the vibrations of the æther which arises from the character and dimensions of the minute tubes, and interstices, containing æther, which traverse the substance of conducting or transparent media, may indeed be roughly compared to the effect produced on sound vibrations by air confined within pipes, and spaces surrounded by substances impervious to air. A full discussion of this subject, however, requires a more exact consideration of the character of the vibrations or movements associated with light, heat, and electricity, and therefore it will be deferred till later on.

Before concluding this introductory chapter, however, it will be well briefly to examine how this theory—that æther is a fluid filling the Universe, and permeating all but the minute ultimate particles commonly known as "chemical atoms," and that its vibrations and movements give rise to the phenomena of heat, light, electricity and chemical action, and hence practically give life to the Universe—will agree with a few of the ordinary phenomena of nature taken at random. What, according to this theory, would "latent heat" be? It would be the heat expended and destroyed (as far as its usual manifestations go) by bringing about such a position of atoms or particles in the æther as will, when they are restored to their old position, cause vibrations in the æther equal to those that disappear when the atoms or particles are so disposed. To take an example: if ice is turned into steam a large amount of heat becomes latent. That may be simply explained by the fact, according to the above theory, that the particles of ice, from being either motionless, or more probably in a lower or more restricted condition as regards movement, are separated from one another, and set moving rapidly among themselves and in space. Now, when one moving body imparts energy to another body, it necessarily imparts to the other body just the amount of energy that it loses. Here it is the æther or surrounding matter that gives the motion, or additional motion, to the particles of water, and in producing that motion heat vibrations are diminished, or, in other words, heat becomes latent. When, on the other hand, particles of steam are brought to a state of comparative rest in ice, they lose motion, and the æther or surrounding matter acquires energy, the heat vibrations arising in the surrounding æther, &c., constituting the form of energy produced. Heat and cold, produced by chemical changes, can evidently be explained in a similar way; but in this case, according to our theory, certain portions of æther are enclosed, at a lowered pressure or momentum, between combined atoms, and of course the loss of motion undergone by enclosed portions of æther must be taken into account, when atoms combine, or their increase of motion, when combined atoms are dissociated from one another. It is not necessary here, however, to go more into detail as to the various processes involving the change of latent heat into sensible heat, or *vice versa.* Enough has been said to show that the present theory gives a highly probable and rational explanation of the phenomena connected with what is called "latent heat." The subject will be more fully dealt with later on.

The great difference which different substances display as regards their capacity for allowing the vibrations of the æther to pass through them, either modified or unmodified, requires, for full explanation, that the character of the various vibrations or movements (those, for instance, associated with heat, light, electricity, &c.) should first be determined. The discussion of this subject is, however, too difficult and complicated to be dealt with in an introductory chapter.

There are, nevertheless, cases in which the determination of the character of the vibrations is not so essential, and it is well to consider how far the results of observation agree with the theory now propounded, merely assuming that there are vibrations of æther giving rise to the well-known manifestations of heat, light, &c.

We have argued that atoms or ultimate particles of matter are impermeable to æther. If this be so, it would seem that, when atoms, or combinations, or conglomerations of atoms, are muddled up together without any methodical arrangement, great interruption and breaking up of æthereal vibrations of all kinds would result. Amorphous finely-divided powders present some such condition. Therefore, the above theory requires that they should be bad conductors of æthereal vibrations, whether due to heat, light, or electricity. Is that so? Roughly speaking, it certainly is so, and that in a well-marked degree.

On the other hand, solids with a very definite structure and methodical arrangement of the constituent particles should evidently, as a rule, readily transmit æthereal vibrations; and, since the structure determines the size, nature, &c., of the æthereal channels and spaces enclosed within a substance, one would expect to find that a definite substance would transmit some vibrations and stop, or alter, others. The analogy of sound vibrations in air would lead us to anticipate some such result. Actual facts quite accord with this, for observation shows that solids which are good conductors, or very transparent, have a very definite structure often apparent even to the naked eye, as in the case of certain metals, glass, &c. That a substance such as glass should be very transparent to light and at the same time very resistant to heat vibrations is quite natural, and tends to strengthen the argument in favour of the above theory, since, evidently, an arrangement of particles which would favour vibrations in one plane would effectively impede vibrations in another plane, and so on. The mode of fracture of ductile metals and of glass give *prima facie* evidence of an important difference in the arrangement of the particles, and consequently in the nature of the intervening channels of æther. Without going into details, which would require for their full determination that we should first ascertain the nature of the vibrations or movements of light, heat, electrical discharges, &c., it may be stated, in the meantime, that a definite and, for the most part, a simple structure characterises the best conductors of all æthereal vibrations. It is, however, not the structure of the body itself so much as the size, form, &c., of the intercepted channels, or spaces, filled with æther that, according to this theory, determine the properties of substances in this respect.

Taking another phenomenon, that observed when an electric discharge is passed through a vacuum tube. A vacuum tube must evidently by this theory be a tube filled with æther more or less pure. Electrical movements passing out of the channels, full of æther, in the wire conveying the current, would evidently spread out freely in the tube. This is exactly what is seen to be the case by the luminosity arising from the particles of matter present as impurities in the æther. These impurities, by the resistance they interpose, convert the electrical movements into light vibrations just as happens in an ordinary electric lamp. The more complete the vacuum, that is to say, the fewer the particles of ordinary matter present, the less should be the luminosity. Experiment proves that as the impurity is removed the luminosity disappears.

Examples might be multiplied almost indefinitely, showing that the theory here propounded gives a simple explanation of fundamental phenomena, so familiar to us, and so little understood; but it will be better to proceed in a more methodical manner now that the general outline of the theory has been indicated.

Before concluding this introductory chapter, however, a few words may be said about the existence of æther, as the assumption of its existence is the fundamental basis of the present theory. It may be said that we have no solid evidence of its existence. Do we not see its movements in the light and in the motions of the heavenly bodies? Do we not feel them in heat and electrical discharges? Or are light, heat, &c., mere nothing, mental delusions, physical sensations without a material cause? It is, indeed, because the æther is within us, as well as without us, because it fills the whole Universe, and leaves no place empty, that we have hitherto failed to recognise it fully as a material entity, and to connect it directly with its many and all-important manifestations, most of them so well known to us.

CHAPTER II.

Atoms, Molecules, and Gravitation, in Relation to Æther.

In considering the subject of the relations of matter (or, rather, of the rest of matter) to the æther, it is convenient, for the sake of simplicity, to begin with the smallest subdivisions of matter with which we can be said to have any acquaintance at present, that is, with chemical atoms, and the compounds formed from them.

A chemical atom, according to the present theory, may be described as a particle of matter which occupies the whole of the space in which it is situated, and which excludes therefrom not only air, and other ordinary material substances, but also æther itself.

In order to explain, in regard to atoms, that fundamental property which is called weight, or gravity, it is assumed, according to this theory, that individual atoms, whether isolated from one another, or closely adherent to other atoms, are situated within a large volume of æther, extending to the furthest limits of the Universe, which by its motion imparts to them a resultant impulse towards the centre of the earth. This constitutes what is known as weight. It has long ago been proved that in a vacuum (*i.e.*, in æther) all bodies fall with equal rapidity towards the centre of the earth—a piece of lead falling no faster than a feather—and it may, therefore, be reasonably assumed that all atoms which displace equal amounts of æther have equal weight. There are, however, many and convincing reasons for believing that the atoms of different chemical elements have widely different weights. Thus the atom of oxygen is believed to be 16 times heavier than the atom of hydrogen, and the atom of gold about 196 times heavier. The explanation, then, which suggests itself as accounting for this difference, according to the present theory, is the very simple one that the heavier atom is of larger bulk, and displaces more æther than the smaller atom. From this it follows that the size of chemical atoms are in the same ratio as their weights, or, in other words, that an atom twice the size of another weighs twice as much, and so on. The size of an atom of oxygen is accordingly 16 times as large as an atom of hydrogen, and an atom of gold 196 times as large.

There is, unfortunately, at present no direct method of measuring the size of chemical atoms, or of rendering them visible to the human eye, and we can, therefore, only proceed by adopting the above as a hypothesis, and by examining how far such a hypothesis is capable of being reconciled with facts commonly regarded as proved, and with natural phenomena which can be more directly observed.

When chemical elements (*i.e.*, substances composed of atoms all of the same character) are in the gaseous condition, and at such temperature and pressure that the atoms are quite dissociated from one another, it may be assumed that the weight of equal volumes of the different gases will be exactly in the same ratio as the weight of the atoms individually, if volumes are measured under equal circumstances of temperature and pressure, just as the weight of a cubic centimetre of hydrogen is in the same ratio to a cubic centimetre of oxygen as a cubic metre of hydrogen is to a cubic metre of oxygen. The reason why this is so need not be entered into here. This is quite in accordance with Gay Lussac's Law, which may be stated as follows: "The weights of the combining volumes of gaseous elements bear a simple ratio to their atomic weights." For combination takes place, according to this theory, by a cohesion of atoms in a way already explained, that is in a simple ratio to their atomic weights, and consequently in a simple ratio to the weights of the volumes entering into combination, for that is in the same ratio as the weight of the atoms individually, according to the above statement.

Avogadro's Law is often stated as follows : "Equal volumes of all the different gases, both elementary and compound, contain the same number of particles or integrant molecules"; or it may also be expressed as follows : "The number of atoms contained in a given volume of any gaseous body must stand in a simple relation to the number contained in the same volume of any other gas (measured under equal circumstances of temperature and pressure)." Now, with regard to gaseous elements this follows from the above statement that equal volumes of different gases are in the same ratio as regards weight as the individual atoms. As regards compound gases, it must be remembered that, according to this theory, a molecule of a compound gas is a combination of two or more atoms, which are held together by æther, just as larger bodies with closely adapted smooth surfaces are held together in actual experiment. This being so, the weight of the component atoms would not be appreciably altered by their entering into such close juxtaposition, as their bulk would no doubt remain the same. This quite agrees with the accepted law that "the molecular weight of a compound is the sum of the atomic weights of the component parts." The molecules may, however, in the combined state be regarded practically as though they were elemental atoms, since the very small amount of æther fixed between component atoms may be neglected. We may therefore regard a compound molecule as having a molecular weight comparable with the molecular weight of hydrogen, just as the atomic weights of elementary gases are comparable with the atomic weight of hydrogen. Since the molecule is the smallest portion of matter which exists more than momentarily in the free state, a comparison of the weights, or densities, of gases is a comparison of their molecular weights, and not of their atomic weights.

Consequently, when the molecule consists of more than two atoms, in the case of an elemental gas, the atomic weight is not half the molecular weight as ascertained by finding the density, and similarly, *mutatis mutandis*, not when the molecule consists of only one atom instead of two, as usually is the case.

Before proceeding to consider more complicated matters, such as the effect of heat or electricity on the relations of atoms and molecules to one another, it will be convenient to examine how the effects produced by simple pressure agree with the theory proposed. Elementary gases are, as we have already indicated, composed of detached molecules floating in æther. Now, the first effect of pressure under such circumstances will obviously be to bring the molecules closer together, since they cannot pass through the compressing body to any extent, while the æther does pass through freely. While the molecules still remain with free space for their movements, it seems natural that doubling the pressure should halve the volume, or that the volume should vary inversely as the pressure, the temperature being constant. But obviously this would cease to be the case when the molecules were brought into close opposition, so that their movements are no longer free. This condition of affairs, however, is associated with a change of character in the gases. They cease to be gases: they become liquid and ultimately solid. The liquid state continues while the molecules can still move freely in reference to one another within very restricted limits. When the molecules become fixed in their position, as regards one another, they assume what is known as the solid state. In these cases the adhesion between the molecules is similar in character to the adhesion between atoms in chemical combination, but with this material difference, that between the adhering surfaces may intervene, not æther alone, but air, gases and other substances grosser than æther. The limit of compressibility—or, at all events, of appreciable compressibility—comes when nothing but æther can intervene between the molecules, and this constitutes chemical combination, or a condition indistinguishable from it. Diminution of pressure naturally produces no striking change after the gaseous condition is produced, as it can only mean widening the distances between the already detached molecules; unless, and until, it reaches the point when the pressure retaining the atoms in combination becomes overcome, and we should then have complete dissociation of chemical compounds into their elementary atoms. The variations from Boyle's Law, alluded to above, are such as to support the theory now propounded; for it is found that the law becomes modified when gases approach liquefaction, as would almost necessarily follow from the present theory. When molecules become adherent to one another, so as to produce the liquid and solid conditions, another factor of the greatest importance comes into play, and that is the *shape* of the molecules. Molecules of a spherical shape pressed together will obviously produce results differing from that produced by molecules shaped as cubes, pyramids, discs, cylinders, &c. An attempt will be made later on to show that the shape of chemical atoms and molecules are prime factors in determining the properties of different substances, but at present it need only be alluded to. The well-known fact that gases are freely absorbed by liquids and by solids argues in favour of the idea that they are composed of particles with intervening interstices, through which the gaseous particles can enter, but a full discussion of the exact nature of such absorption is not required here.

From what has been said already, it appears probable that no atoms exist smaller than the atoms of æther, if the latter is itself composed of minute atoms, as seems almost necessarily the case. For such atoms, if smaller than the atoms of æther, would be less heavy than the ætheric atoms, and consequently would pass up against the current of the æther, and further from the centre of the earth into space. Again, the largest atoms and molecules, which are also the heaviest, will evidently have a much greater tendency to become fixed together into solids. The tiny little light atoms will more readily flow about in a detached condition. Let us see if this is so in regard first of all to the so-called chemical elements! Are those with the lightest atoms, that is with the lowest atomic weights, more apt to be gaseous; those with intermediate atomic weights liquid; and those with the highest atomic weights solids? In general that is so, but there are several important exceptions, and it is incumbent on us to show why there are such exceptions. It is an old saying that the "exceptions prove the rule." That is to say—the causes giving rise to the exception, being proved to be such as would produce a deviation from the rule, a strong argument is added to show that the rule is still exerting its tendency although for the time overridden by other rules. Let us then set forth in the form of a Table the chemical elements at present recognised, with their atomic weights in ascending series and their condition as gases, liquids or solids in parallel column. When we reach those with an atomic weight above 40 we find that all, without exception, are solids, except mercury, which, with an atomic weight of 198·5, is a liquid, and is, in fact, the only element liquid at ordinary temperatures. The elements with atomic weights up to 40, as appears from the following Table, give a nearly equal number of gases and solids; but no solid appears before an atomic weight of nearly 7 is reached, and no gas above 40, unless Krypton and Xenon.

It must hence be admitted that elements with a low atomic weight are much more disposed to be gaseous than those of higher atomic weight, at ordinary temperature and pressure. This quite accords with the theory that their ultimate particles, or atoms, are smaller than those of elements with higher atomic weights. But how are we to surmount the difficulty that arises owing to the presence of so many solid elements of low atomic weight? Obviously, the size of the particles is not the only factor tending to prevent their free movement in respect of one another. The shape of the

TABLE I.

Name of Element.	Atomic weight (H=1).	Character.
Hydrogen	1·0	Gas.
Helium	4·0	Gas.
Lithium	6·98	Solid.
Glucinum	9·03	Solid.
Boron	10·9	Solid.
Carbon	11·91	Solid.
Nitrogen	13·93	Gas.
Oxygen	15·88	Gas.
Fluorine	18·9	Gas.
Neon	19·9	Gas.
Sodium	22·88	Solid.
Magnesium	24·18	Solid.
Aluminium	26·9	Solid.
Silicon	28·2	Solid.
Phosphorus	30·77	Solid.
Sulphur	31·83	Solid.
Chlorine	35·18	Gas.
Potassium	38·86	Solid.
Argon	39·6	Gas.
Calcium	39·8	Solid.
Bromine	79·36	Liquid.
Mercury	198·5	Liquid.
All other elements	43·8—236·7	Solids.*

* Except Krypton and Xenon.

particles must evidently have a great influence as regards their free movement together. Flat plates would sooner clog one another's motion than spherical bodies of the same weight and material. Possibly, indeed, the condition known as the "liquid" state requires particles of a more or less rounded character. And, if this be so, the exceptional liquidity of mercury (at ordinary temperature and pressure) among the elements, may well be explained by supposing that the atom of mercury is a spherical one. This is not a mere gratuitous assumption, for mercury is generally held to have the remarkable peculiarity of not joining its atoms, two and two, to form molecules, like most other elements; but is said to have molecules consisting of only one atom each. If the atoms are spherical it is easy to see that the cohesion of surfaces, to which in this theory we attribute the formation of molecules, would not readily occur in any stable fashion. But we must defer the discussion of liquidity, &c., for the present. To return to the reasons why we find elements of low atomic weight existing as solids, at ordinary temperature and pressure, one cannot help being struck by the fact that several of the most remarkable instances of this are elements which have the property of developing allotropic forms. Boron, carbon, phosphorus and sulphur are well-known instances of this peculiarity. Now, such diversity of character as exists between the diamond and charcoal, and which in many respects exceeds the diversity between different elements, can best be explained by supposing the packing together of atoms or molecules in quite different manner. In some cases it may reach the degree of actual chemical combination between two or more molecules of the same element; but, in most cases, it is probably a massing together of the molecules so as to produce considerable cohesion, although not so intimate a cohesion as that existing when all but minute quantities of imprisoned æther are excluded; in other words, when true chemical combination has occurred. It needs but little explanation to show that a number of minute atoms, which alone would be very far from filling, in a solid fashion, the space occupied by a definite number of them, might easily be built into a structure which, with considerable intervening spaces, would nevertheless be solid and fixed in character. Let us take carbon as an example, and let us suppose that it is composed of atoms of a cubic or at all events rectangular shape. The shape may be taken at this stage merely as a hypothesis. Later on the subject of the shapes of the different atoms and molecules may be dealt with. It is evident that cube-shaped atoms would very readily adhere by their surfaces so as to form masses of several atoms sticking together so that a result, as regards solidity, similar to that arising from the larger size of the ultimate atoms of elements with higher atomic weights, is produced. Such a supposition as we have made above is supported by the fact that carbon atoms when piled together in regular fashion make an intensely hard mass (viz., the diamond). When irregularly jumbled together, as in charcoal, we have formed a porous, but still solid body—namely, charcoal. A comparison of the different weights of a definite bulk of these two admittedly identical chemical materials shows how solidity can exist in cases where the space occupied by the solid mass is but very incompletely filled with the actual impenetrable atoms of the substance. A child's set of cubes thrown in a heap into the box occupy much more space than if neatly fitted in order. It appears, therefore, that the fact of elements of low atomic weight being solid, at ordinary temperature and pressure, is easily explained by a distinctly probable hypothesis, without at all disproving the supposition which must follow from our theory that elements of low atomic weight, that is, with atoms of small size, are more apt to assume the gaseous form than those of higher atomic weight, that is, composed of atoms of larger size. On the other hand, if we found elements of very high atomic weight, that is, with atoms of large size, readily becoming gaseous, it would be distinctly harder to explain beyond moderate limits. As a matter of fact no element, with a higher atomic weight than 40 is a gas at ordinary temperature and pressure.

Of course, the same rule should apply, with due reservation, to the molecular weight of compound bodies, and if we take a series of compounds, such as are afforded us in organic chemistry, the compounds with lower molecular weight should be gaseous, and those with higher molecular weight solid, with liquids intervening if the nature of the compounds is consistent with liquidity. (Liquidity, as we have already remarked, introduces special considerations, which will be discussed later on.) The paraffins, the olefines (not to multiply examples), have this characteristic in a most convincing manner. The lower members of each series are gases at ordinary temperature and pressure, and the higher ones are solids, with liquids intervening.

Enough has been said to show that a high atomic weight, and a high molecular weight tend to cause solidity in a substance, other things being equal; but it is quite evident, at the same time, that the atomic or molecular weight is not the only factor concerned in determining whether or not a given element or compound is a gas, a liquid, or a solid. According to the present theory, it would seem that the shape of the atoms or molecules must be of great importance in regard to the determination of solidity, &c., as well as their size (*i.e.*, the atomic, or molecular, weight).

This appears from what has already been said, and the way in which the shape of the component particles may affect the condition of a substance as regards solidity, &c., has been briefly indicated.

We may, therefore, now lay down the following law as governing the question of solidity, &c., in any substance:—

> *I.—The condition of chemical elements or of chemical compounds, at similar temperature and pressure and under similar conditions generally, depends on their atomic or molecular weights* (*that is, on the size of their atoms or molecules*) *and on the shape of their atoms or molecules.*

We may also deduce probable inferences, as regards chemical activity, from the size and shape of chemical atoms and molecules. For, if chemical combination is in its essential nature a cohesion of atoms, and groups of atoms, after the fashion described above, it must follow that the smaller chemical atoms will, in general, be more active chemically than the larger atoms; for they will more readily come into the intimate contact necessary for chemical reactions, and will, in their simpler compounds, be more readily knocked out of their position by heavier atoms when they are not so arranged as to withstand such assaults. Here, again, the shape of the atoms will be an all-important factor. Compare, for instance, the cohesion which would occur between two atoms of a disc shape, like two smooth pennies, and that between two spherical balls. The shape obviously would be enough, in such a case, to completely overshadow the influence of the size. If, however, we take series of elements, or compounds of very similar properties, and therefore, presumably, in most cases, of similarly shaped atomic or molecular structure, we find distinct evidence of the steady influence of the size of the atoms or molecules on the chemical activity. Take chlorine, bromine, and iodine, which are very similar in their properties. In accordance with the previous rule as to solidity, they are gaseous, liquid, and solid in order of atomic weights, and in their chemical activity a corresponding difference appears. Among metals we may take lithium, sodium, and potassium as examples. Metallic lithium is more active than sodium, and sodium than potassium, and the activity of these, as compared with metals with much higher atomic weight, is very marked.

In the series of organic compounds, which are almost identical in character, differing chiefly by steadily growing molecular weights, the chemical activity of the lower terms of each series is much more vigorous than that of the higher ones. When, however, we compare substances with different modes of structure, the element of shape at once comes in and disturbs the result which would arise from altered size alone. We need not enumerate examples in proof of the above, since numbers of such will occur to every student of chemistry. We will, therefore, assume as established by strong probability the following law :—

II.—The relative chemical activity and chemical properties of chemical elements or chemical compounds, at similar temperature and pressure, and under similar conditions generally, depends on their atomic or molecular weights (that is, on the size of their atoms or molecules) and on the shape of their atoms or molecules.

It is not meant by the two laws laid down that there are no other factors influencing the properties of elements and compounds except those that have been mentioned; but it is meant that the size and shape of the component atoms or molecules are of the highest importance in determining such properties, and that the character as to size or shape exerts its influence throughout, no matter what the conditions present may be, provided the shape and size of the component atoms or molecules are not altered thereby.

CHAPTER III.

Chemical Changes and Reactions in Relation to Æther.

We have already very briefly sketched the way in which molecules and chemical compounds are formed, and we now proceed to consider what it is that determines the occurrence of chemical changes and reactions. In other words, we have to consider why an atom, or a molecule, leaves its state of cohesion to one atom, or molecule, and takes up a similar position in relation to a different atom, or molecule. It is evident, in the first place, that force of some kind is necessary to displace an atom, or molecule, which is chemically combined with another atom, or molecule. Vibrations of the æther, which act as a connecting medium between the combined particles, may obviously break them asunder, and the effect of the æthereal vibrations or movements known as heat, light, electricity, &c., are well recognised as agents for producing dissociation and separation of chemical atoms and molecules. There is, however, something in the nature of certain elements and compounds which makes them act quite differently from one another in regard to combining with other elements or compounds. This difference is independent of temperature and luminous or electrical conditions. An attempt has been made to explain it by saying that different elements and compounds have different degrees of "chemical affinity" for certain other elements or compounds, and this mode of expression is in many ways a very convenient one; but it is merely a name for the class of phenomena indicated, and not a true explanation of their nature. When the completely dissociated atoms of two chemical elements are brought into intimate contact they will combine if their surfaces are such as to allow of the form of cohesion which has been described as the essential feature of chemical combination. If the dissociated atoms of more than two elements are brought into ntimate contact (with the amount of motion imparted to them by the usually existent vibrations of the æther arising from heat, &c.), the ultimate result will be their combining in the firmest manner possible, because when the firmly-combined particles come into collision, as they constantly do in solution or in the gaseous state, with the loosely-combined particles, the latter will tend to break up, while the former will remain unmoved. In this way, more or less rapidly, a permanent condition is arrived at, and further changes no longer take place between the intermingled atoms or molecules. Now let us suppose three elementary substances—*a*, *b* and *c*—brought into close atomic or molecular contact, as, for instance, in solution or in the liquid or gaseous state. Let two of the three be capable of combining with the third, thus—$ac+bc$. What would determine the result if there were enough of *c* to combine with either *a* or *b* but not with both *a* and *b*? In the old way of speaking, it may be said truly enough, that *c* would combine with *a*, or with *b*, according as *c* had greater affinity for *a* or for *b*. What, then, constitutes such affinity? If our theory is correct, the size and shape of the atom would seem to be the only qualities likely to influence the relative affinity under given external conditions, and we may then lay down, as a third law, the following :—

III.—The affinity of atoms or molecules one for another, and the firmness with which they combine at similar temperature and pressure, and under similar conditions generally, depend on their atomic or molecular weights (that is, on the size of the atoms or molecules) and on the shape of the atoms and molecules.

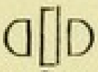
Law II., as given in the previous chapter, perhaps includes this law; but it is better to deal with it separately as involving very important special issues. Bearing in mind our definition of the nature of chemical combination, it seems evident that two thin smooth plates of considerable size would combine together with great firmness, and, with exactly similar plates, the combination between two large plates would be firmer than between two smaller ones. On the other hand, small spheres can hardly be conceived capable of combining at all with one another in any permanent fashion. Unfortunately we have no clear data showing the shapes of the various chemical atoms or molecules, and since the shapes are of the most extreme importance in determining the affinities, it makes the task of assigning due influence to the weights of atoms or molecules (that is, to their size) very difficult indeed. Were it not for this we might arrive at good results by comparing the affinities of a number of elements for one and the same element. We might, for instance, compare the affinities of various atoms and molecules for hydrogen, and note the relation between these and the atomic or molecular weight. To make the matter as simple as possible, we might take other monovalent elements, which according to this theory are made up of atoms with only one surface each, such as would form a basis for attachment to other atoms and observe their affinity for the monovalent hydrogen. If the adhesive or combining surfaces of all monovalent elements were of the same size, or even of sizes proportional to the atomic weights, we might in this way arrive at conclusive results; but in all probability this is not so, and therefore our data are insufficient. Under the circumstances, the only way in which we can well hope to arrive at any clear indication of the influence of atomic or molecular weight (*i.e.*, size) on affinity seems to be by comparing substances very similar in general characteristics but differing in atomic or molecular weight. No results thus obtained can carry much weight, however, in the face of all the surrounding uncertainty. We may, at all events, infer from our theory that the size as well as the number, and general characters of the surfaces of attachment of atoms or molecules will modify largely the influence of the size of the atoms or molecules on the stability of their combinations with given atoms or molecules ; but until we know the form of an atom or molecule we cannot make more than a mere guess at the area of combining surface or surfaces which it possesses. The smooth surfaces of attachment may also conceivably be smoother in one element than in another, and, of course, the smoothness of adhering surfaces makes a great difference, as is well known, in the firmness of the resulting adhesion. In consequence of these difficulties it will be unprofitable to discuss at much length the influence of the size (*i.e.*, the atomic or molecular weights) of atoms or molecules on their mode of entering into combination until we arrive at some probable conception of the actual shapes and characters of some of the more important chemical atoms and molecules.

In the meantime, however, we may discuss the bearing which the present theory has upon some of the recognised laws and conditions which characterise chemical combinations and reactions. There can be no doubt that chemical reactions and combinations take place much more readily when the chemical substances concerned are broken up into the smallest available particles, and are not merely brought into contact in solid lumps. This can, of course, be verbally explained by saying that chemical action takes place between atoms, &c., only at infinitely small distances, but it is a more intelligible explanation to say that, since chemical combination consists in the close cohesion of smooth surfaces, it is necessary to render the surfaces accessible to one another, in order that the conditions essential to cohesion may arise. The effect of heat in promoting chemical changes of course necessarily follows from the present theory, as the movements of the æther break up existing cohesions, and the detached particles gradually settle down into more permanent conditions of cohesion, unless, indeed, the movement of the æther is sufficient to cause complete dissociation, and so to overcome any tendency of the particles to settle down into new conglomerations. Cold—*i.e.*, motionless—æther leaves existing cohesions undisturbed, and so checks chemical changes. In asserting that the chemical properties of atoms and molecules depend on their shape, as well as on their size, we fortunately are able to point to instances in which the size (or atomic weight) of atoms remains the same, but in which the atoms, taken together, undergo great changes in their properties. The so-called allotropic forms of elementary bodies are examples of this, and so, in organic chemistry, are the various compounds which, while consisting of identically the same set of atoms, are, nevertheless, quite different from one another in their properties, owing to the fact that the mode of arrangement of the constituent atoms is different, with the result that the shapes of the resulting molecules differ widely. The present theory obviously gives a perfectly plausible explanation of this class of phenomena, which is otherwise very unaccountable.

One of the first examples of allotropic forms that occurs to one's mind is ozone. This is said to consist of a sort of condensation of ordinary oxygen. Three atoms are supposed to form a molecule in this condition, and it is accordingly regarded as O_3, in chemical nomenclature. Now, according to the present theory the atom of oxygen, as being a diad, has two surfaces capable of acting as surfaces to which other atoms can adhere. For reasons which need not be gone into here, it may be supposed to be a disc, somewhat like a penny, or a thin plate. We then have the ordinary molecule of oxygen somewhat like the following figure—II, while ozone would be as represented thus—III. One would naturally infer that the latter would be more readily broken up into its constituent atoms, and hence be more active chemically, and this is the case when we compare ozone with oxygen. Carbon, phosphorus, &c., afford examples of allotropic forms of the same element, and it is worthy of note that no monovalent element shows any allotropic form, no divalent element shows more than two such forms, and so on. This is quite in harmony with the view that the valency of an element depends on the number of surfaces, suited for cohesion, which are possessed by the element.

An important difference which exists between chemical elements, and which at once strikes any observer, is the difference in their power of piling up chemical compounds with other elements. Some elements, for instance, appear capable of forming only a very small number of compounds, while others, and notably carbon, seem capable of an almost indefinite super-addition of atoms and groups of atoms. This marvellous power of constituting the basis for innumerable variety of different compounds is one of the most important properties which an element can possess. It is this power which enables carbon to become a sort of groundwork of the whole of living things, both animal and vegetable. Why has carbon this wonderful power? Are we to be content with saying that "organic" chemistry is practically identical with the "chemistry of the carbon compounds"? We have already laid it down as a law that the chemical properties of elements depend on their size (or atomic weights) and on their shape. There is nothing in the atomic weight of carbon which seems likely to give the clue to its mighty constructive capacity. Is it the shape of the carbon atom, then, that endows it with such important properties? The Author contends that it is. It follows directly from the present theory that a set of cubic or rectangular-sided atoms will, in all probability, be capable of forming an almost infinite number of combinations, while atoms with only one flat surface, or two flat surfaces, and so on, must be quite limited in the number of stable combinations which they can constitute. One cannot help feeling, then, that here we have a crucial test of this theory. If carbon cannot be regarded consistently as ultimately composed of rectangular atoms with six flat smooth surfaces, one might almost despair of the theory. But, at the outset, we have the benzene ring, the C_6H_6 radical, as almost in itself enough to make the theory probable on *prima facie* grounds. The fundamental conception of this theory was in no way arrived at by any consideration of the benzene ring, but it gives such a simple, such a plausible, explanation of this most important fact in the chemistry of the carbon compounds that it cannot be lightly cast aside by anyone who realises the great significance of such a coincidence. The simplicity of this theory of course insures its earning the hearty contempt of philosophers whose conceptions are fast bound with links and side-chains; but it is nothing new to find that the mysteries of nature, which have seemed too intricate to be traced by the greatest minds, are after all capable of being understood by babes and sucklings when seen with eyes free from the mists of prejudice and preconception. The child, when he makes marvellous structures with his cubes or wooden bricks which he cannot make with his marbles, has before him an object-lesson showing one of the great secrets of nature. Nature piles up its carbon atoms just as he piles up his bricks, but with infinitely greater skill. In order to show that the combinations of carbon with other elements are consistent with the above idea of the shape of carbon atoms, it is almost essential to know also the shapes of the atoms of the other elements concerned, but the characteristic of carbon, mentioned above, is independent of the shape of the other atoms. We have already mentioned the allotropic forms of carbon. The amorphous carbon can readily be explained as consisting of carbon molecules jumbled up together without any regular arrangement. Graphite, again, can be regarded as formed of carbon molecules arranged in a regular form, but in such a way as to leave intervals between the constituent rows of molecules. Diamond, finally, must be regarded as formed of carbon molecules fitted together in a most compact manner, so as to leave as little space as possible. Now, on the supposition that carbon atoms are of the form we have assumed, it is easy to infer that diamond would be one of the hardest possible substances, as is actually the case. Moreover, the much more complete exclusion of æther in a body thus constituted than in a body formed of ill-fitting components, will account for the powerful reflecting power of diamond for the vibrations of æther known as light, and the consequent brilliance of the diamond. The properties of carbon, as regards heat and electricity, are also quite in accord with what would seem to follow naturally from the above view as to the shape of carbon atoms. Silicon has many properties in common with carbon, and there is much probability that the atoms of silicon are similar in shape to those of carbon, or at all events of such a shape, with rectangular flat surfaces, as to allow of a firm building together of the atoms without appreciable channels intervening. Accordingly we find the amorphous variety, the crystalline form resembling graphitic carbon, and the third form, which may be compared to the diamond in the case of carbon.

But if atoms, which have shapes suitable to their firm piling together, exhibit qualities such as those of carbon, we ought to find the reverse with atoms which have shapes ill-suited to such close adaptation of their surfaces. Now, there is much in the crystallisation and other characters of common phosphorus to lead us to assume that its atoms are many-sided, and such that they can only be arranged in piles with the inclusion of considerable irregular spaces filled with æther. It might, therefore, be surmised beforehand that phosphorus would be chemically active, but easily displaced from its simple compounds in most instances. The phenomenon of phosphorescence is evidence of structure such as that described above, but this will be more fully dealt with in a later chapter. Friction of phosphorus easily produces flame, and this is readily explained by the displacement of phosphorus atoms, stuck together is an unstable fashion. The imprisoned æther between the phosphorus atoms is, by friction, &c., readily put in communication with the freer æther, and heat and light vibrations are consequently engendered, since the imprisoned æther is under a different pressure from the generally diffused æther. Nitrogen is another example of an element with many combining surfaces and the consequent properties are similar. It is only when the atom of one of these is completely hedged in by other atoms that stable compounds are obtained. Physiologically these many-sided atoms exhibit poisonous properties while they continue in unstable combinations. Their poisonous properties disappear when they are built into a stable mass with atoms of a simpler shape. A large number of instances occur in which one element refuses to combine with some other one, or exhibits great inertness towards it and disinclination to combine. According to our theory this must arise from the combining surface or surfaces of the one not being readily adaptable to that or those of the other. Evidently it will be among the many-sided atoms that this inertness will be most observed. Discs, plates, cubes, &c., should not show exceptional inertness if the theory is on solid foundations in this respect.

According to the view we take of the fixed character of atoms, as regards shape as well as size, there can be no change in the number of combining surfaces in the case of atoms of a definite element, and, therefore, it is necessary to examine how this can be reconciled with the apparent change in the valency of certain elements. This can only be satisfactorily explained, in general, when two or more atoms are involved. It is then easy to see that two or more atoms, cohering, may present a different number of combining surfaces from those presented by a single atom; and different numbers according to the mode of disposition in the case of multiple atoms of certain shapes. As the valency depends entirely on the number of combining surfaces available as connecting links with other atoms or molecules, this change becomes almost a necessary consequence of our theory. This theory also involves the existence of the well-known peculiarity of so-called "nascent" elements. When an element is in the molecular condition there are at all events two surfaces, one of each atom, not directly available for cohesion with other surfaces. When the element is in the atomic state such surfaces are free. Hence the chemical activity of dissociated atoms must, by direct deduction from our theory, be greater than that of fully formed molecules. This is quite in accordance with recognised facts. It will have already occurred to a reader that this theory makes no distinction between the cohesion of two similar atoms to form a molecule, and the cohesion of two dissimilar atoms to form an ordinary chemical compound, beyond the circumstance of the similarity of atoms in the one case, and their dissimilarity in the other. That there is no fundamental distinction between the cohesion of similar atoms and that of dissimilar ones is shown by the fact that, under certain circumstances, similar atoms can combine in such a way as to form a compound differing in general characters from the result of the usual molecular cohesion of the same atoms. In all cases where the cohesion of two or more atoms, similar or dissimilar, produces a compound differing in important particulars from the components, the difference in character arises, according to our theory, from the fact that the resulting conglomeration of atoms constitutes a molecule differing in size and shape from the constituent atoms. This change will be produced according to the final result, whether the atoms be similar or dissimilar; but, obviously, the change is likely to be more frequent, and more marked, in the case of widely dissimilar, than in the case of similar, or nearly similar, atoms. In accordance with the above, we find that the same identical set of atoms can in fact form different chemical compounds, in consequence of a difference in the method of their arrangement. This occurs both when the atoms are those of the same chemical element and when they are those of different elements. In the one case this strange phenomenon is spoken of as "allotropism," in the other case as "isomerism"; but the explanation is in both cases the same—namely, that a different arrangement of the atoms produces molecules differing in shape, and consequently compounds differing in important physical and chemical properties. The phenomena of *solution* according to our theory, may be simply explained as the disseminating of molecules, or small aggregations of molecules, through the æthereal channels existing in a liquid, such as water. Insoluble substances are those which by their size, or more frequently perhaps by their shape, cannot pass into the available channels. I do not wish at present to enter into the large subject of the actual shape of individual elements and compounds, but in order to give an example of what I mean by "channels between the molecules of a liquid" I may give an idea of what I think a possible description of the shape of the molecules of that great solvent water. Hydrogen, for many reasons, may with probability be regarded as made up of atoms of a hemispherical shape, D, or of a conical shape, and oxygen atoms, as we have hinted, may be regarded as plates or discs. Water will then be represented by two hemispheres or cones with a plate or disc fitted between the two flat surfaces of the hemispheres, somewhat thus,  or . The result is an almost spherical molecule or double cone, though whether the oxygen plate or disc protrudes beyond the edges of the hydrogen hemispheres or cones, or not, we will not attempt to discuss here. The problem is, most likely, by no means incapable of solution, as we may, perhaps, attempt to show on some other occasion.

Now, it is obvious that a mass of these spherical, spheroidal, or spindle-shaped bodies will leave considerable intervals among them into which small particles can quite conceivably be distributed in considerable quantity by stirring a soluble substance up in the water.

As regards diffusion through membranes, it is evident that small particles will pass through more readily than big ones, *ceteris paribus*; and that the shape will be of the utmost moment in determining whether a given particle will or will not pass through what is simply a fine sieve of a special kind. Such a supposition is strongly supported by the results of experiment. Enough has been said to show that, according to this theory, a hard mechanical conception of the nature of atoms is deliberately adopted, and that, given the size and shape of definite atoms and the characteristics of the intervening æther, the various physical and chemical properties of different substances are regarded as determined by the nature and arrangement of the component atoms, and by the amount and distribution of the enclosed æther.

We might attempt to show how this theory explains or agrees with innumerable physical and chemical laws; but it is enough for our present purpose to give examples sufficient to make our meaning clear, and to leave the intelligent reader to test for himself how far the theory is in harmony with well-established facts.

CHAPTER IV.

Heat in Relation to Æther.

Heat is the name given to the cause of a set of phenomena too well known to require enumeration. The origin of heat has been pretty well proved to consist in certain vibratory movements in the æther as it exists in the various channels and interstices between the molecules of matter. The vibrations of the æther are communicated, in a more or less modified degree, to the material particles, and it is the whole of the resulting movements that constitute together the phenomena of heat as commonly understood. The free movement, in mass, of æther from one place to another gives rise to the phenomena of gravitation, as we have already stated, the grosser particles of matter being simply carried along in the æther. This kind of movement of the æther can be converted into the special movements characteristic of heat, light and electricity, for they are simply varied modes of motion of the æther, &c., under special modifying conditions which will be dealt with in due course. A stone, borne along by gravity through the resisting air, may become red hot by conversion of the movement characteristic of gravity, and derived from the movement of the æther, into the vibrations which constitute light and heat. Electricity can similarly be derived from gravity under special conditions of which we shall speak later on. The acting force, whether it be heat, light, or electricity, that is produced, is derived from the movement of æther; sensible heat, originating from gravity, is produced only at the expense of other forms of motion. The movement of the æther, meeting with resistance from non-æthereal matter, develops heat. As we pass to the limits of the terrestrial atmosphere, where the æther becomes nearer and nearer to purity, and the resistance to the æthereal movements less and less, we find heat more and more disappearing in so far as the manifestations commonly regarded as essentially characteristic of heat are concerned. The unbroken waves of æther in the outer regions of the atmosphere meet with but little resistance, and are but little broken up into the surf-like vibrations which we speak of as heat. The resistance increases more and more as the solid centre of the earth or heavenly body is approached, and heat is more and more developed. In cases where powerful ætheric waves meet with resistance, and are subjected to certain characteristic modifications, vibrations of the definite wave-lengths, &c., which constitute light, are produced in much the same way as heat. Light is convertible into heat, and heat into light, by appropriate means. Some of the small, regular and rapid pulses which emanate as light from the sun, are no doubt derived from larger ætheric waves in some such way as has been indicated. When the light vibrations from the sun fall on a substance such as bricks they are changed into the larger and slower vibrations of heat, the light disappearing as such. Whether the source of light or heat be the sun, or any other source, their nature is evidently in main features the same. Both light and heat consist of vibrations, but differ in wave-lengths, and in the rapidity with which the waves or pulses succeed one another, &c. Having thus briefly alluded to the way in which the æther serves as a basis for gravitating movement, and for the oscillating movements of heat and light, we will proceed to speak of heat alone, and will try to show how our theory agrees with fundamental facts actually observed.

When two bodies of different temperature are brought into contact with one another, heat passes from the hotter to the cooler, rendering the hotter one less hot, and the cooler one less cool, until both reach a uniform temperature. The more rapid vibrations of the hotter body meet with the slower vibrations of the cooler body in the medium of the æther, and the two vibrations, being superposed, produce a vibratory condition of an intermediate degree. This as much as though a mass of water in a state of violent commotion were brought into communication with a mass of water in a more quiescent state. The agitated water would become quieter and the quiet water would become more agitated. The motion of the agitated water tends to become evenly distributed throughout the combined mass. So it is with heat, and the process of interchange is in both cases roughly the same. The tendency which heat has to expand solids, liquids, or gases, is one of the fundamental characteristics of heat. It is, in fact, by the amount of expansion produced by heat, applied to some convenient substance, that heat is usually measured. It is consequently essential that our theory should be capable of giving a rational explanation of this important physical fact. The easiest way to explain the mode by which heat expands bodies is by the analogy of similar recognised phenomena. Molecules floating immersed in æther can clearly be regarded as roughly analogous to solid particles floating immersed in water. Now, supposing a mass of mud immersed in water, and soaked with water, the effect of imparting to the water brisk vibratory movements will be to at once enlarge the mass of mud, and, if the movements are violent enough, to dissociate the particles altogether and to break up the mass. So it is with masses of matter floating in æther, and soaked with it. Moderate heat vibrations enlarge the mass, while with increased violence they break up the mass into its component molecules, and ultimately into the atoms themselves, perhaps.

It is at once obvious, from the above, that the degree of cohesion of the particles or molecules will influence the amount of expansion produced by a definite quantity of heat. Where the molecules, or, still more, where the atoms are quite dissociated from one another, the expansion should be the same, no matter what the molecules or atoms are, as we have to do with what are practically the free vibrations of the æther itself. In the condition which is present in a "perfect gas" we have this state of affairs, and experiment proves that when this condition is attained, or nearly so, all gases expand by heat in an identical degree, while the pressure continues the same for all. Roughly speaking, all gases expand equally by heat; but, as might be expected from our theory, the amount of cohesion between molecules and atoms under ordinary circumstances differs somewhat, and therefore the statement is only strictly true of "perfect" gases.

In the case of gases readily liquefiable, the coefficient of expansion is less than in the case of those less readily liquefiable. This follows directly from the assumption, required by our theory, that liquefaction involves a modified cohesion of the molecules one with another. As air is a fairly "perfect" gas, an air thermometer gives the rate of expansion of fairly perfect gases with fair accuracy. It is found that at constant pressure the air expands $\frac{1}{273}$ part of its volume at zero for each degree Centigrade of rise in temperature, and contracts in the same ratio. From this, if rigidly true throughout, it would follow that at about 273°C. below the freezing point of water, a given volume of air, or of a similar gas, would vanish, as it would no longer occupy any space at all. This is, of course, absurd, but there is, none the less, a meaning in what is called "absolute zero," and the present theory supplies it. Absolute zero simply indicates complete quiescence of æther. If the æther filling the universe sank to absolute rest we may confidently believe that the prevalent temperature would then be about 273°C. below the freezing point of water. Until this happens, therefore (and life will then be non-existent), or until we are able to confine without leakage considerable masses of æther, the temperature of 273°C. below zero will not be attainable. As regards the effect upon air, or upon any other gas, the question of vanishing would never arise since it would ere this degree of cold was reached have become solid, and have ceased to be subject to a law which applies only to perfect gases. Possibly æther itself would ultimately become solid, for, according to what we have said, the essence of solidity probably is the absence of relative motion between the ultimate particles of the solid. Speaking of gases, the molecules having been brought closer and closer together as the gas contracts with cold, they must necessarily form a solid mass before the occasion for departing from existence would arise. The more a gas expands, or becomes rarefied, the more it acts as a perfect gas, since the dissociation of the molecules or atoms is more complete in the rarer gas.

From our theory, and from what has been said, it follows that the coefficient of expansion, or rate of expansion, of a perfect gas by heat, must be greater than that of any other gas or of any liquid or of any solid. Experiment shows that this is so. Liquids must evidently follow next in their rate of expansion by heat, and solids must come last of all.

As is well known, the expansion of gases, liquids, and solids, can be used for the purpose of measuring the actual temperature of the air and other substances. For ordinary purposes a liquid is found most convenient, as the amount of expansion is sufficient to be easily noted, and not so great as to require instruments of too large a size. The great drawback to liquids, as compared with gases, is their tendency to expand at a different rate at different temperatures. The reason for this has been already indicated. The liquid which above all others has been used for the purpose of measuring temperature is mercury. This is largely due to the constancy of the rate at which it expands within ordinary limits of temperature. Now, it must be evident from our theory that liquids consisting of dissociated atoms will, other things being equal, give more regular results than ones composed of molecules liable to be more or less dissociated into atoms as heat increases, with a consequent effect on the heat itself. It is therefore interesting to note that mercury which has been selected on purely practical grounds as a means of measuring heat, does, in all probability, possess the peculiarity of having at ordinary temperatures an atomic structure, instead of a molecular one with molecules consisting each of two or more atoms cohering together. Mercury is found to expand almost uniformly between 0°C. and 100°C., while most other liquids are in a varying degree distinctly less uniform in their rate of expansion.

The peculiar exceptional circumstance that water contracts on being heated from 0°C. to 4°C. requires to be mentioned. It no doubt arises from the fact that the piling up of the water molecules into solid ice crystals takes place in such a manner as to involve an increase of bulk owing to the molecules not fitting so closely together in ice as they do in water at 4°C. A similar explanation will apply to other examples of a similar kind. As we pass from liquids to solids, however, the full explanation of the varying rates of expansion becomes more complicated, and we shall not deal with it here beyond remarking that it is quite in harmony with our theory that the expansion of solids by heat should be distinctly more complicated than that of liquids, and the expansion of liquids more complicated than that of gases.

Since heat vibrations separate the atoms, or molecules, of a substance more widely from one another, when expansion is not prevented, there will evidently be fewer in a given space at a high temperature than at a low one, and consequently the weight of a given bulk of a substance is diminished by heat.

As we have no means of measuring heat vibrations more directly, it is usual to estimate quantities of heat by reference to a unit such as the amount of heat required to raise a gramme weight of water 1°C. in temperature. We need not here describe the methods by which the process of measuring is carried out. Now, a gramme of one substance may require more or less heat to raise it through a degree of temperature than does a gramme of another substance. A gramme of water requires more heat than a gramme of any other body, and hence it affords a good standard for reference.

This varying requirement of heat for the raising of the temperature is spoken of as the "specific heat" of a substance. Let us, then, see how far the accepted laws as to the specific heat of gases are in accord with our theory. The specific heat of a gas is approximately the same at all pressures, as shown by Regnault. That is to say, according to our theory, that a gramme weight of the atoms of any one gas will require the same quantity of heat to raise it 1°C. in temperature, whether the atoms occupy a larger or a smaller space, for the volume of a gas varies inversely as the pressure. According to our theory the same amount of æther is displaced by a gramme weight of atoms, no matter what space they are crowded into, so long as the atoms still continue dissociated or the gas quite gaseous. The resistance to be overcome by the æthereal vibrations is therefore the same in this respect. But since the volume to be heated is altered, say, by one-half, the heat should also be altered by one-half, were it not that the pressure has been also altered by one-half in the opposite sense to the alteration of the volume; and so the increase of pressure, by increasing the resistance, neutralises the influence of the diminution of volume. It will be noted, however, that when the volume of the gas is diminished the relative proportion of the æther displaced by atoms to the proportion of æther not displaced becomes increased. In the case of gases this need not be taken into account, though it must exert a progressive influence as the compression of the gas proceeds.

It is admitted that the law is only "approximately" accurate, and, therefore, we may take it that there is not any serious discrepancy between the law and the fundamental axioms of our theory. Put in other words, the above law amounts to this—that the quantity of heat required to raise a given volume of the same gas through 1 deg. of temperature varies directly as the density of the gas; that is, as the number of atoms contained in the given volume. Twice as many atoms, occupying the same space, take twice as much heat to raise them through 1 deg. of temperature.

Up to this we have been considering the case of atoms (or molecules) all of the same size, and we must next consider how an alteration in the size of the atoms affects the position. Regnault further proved that the specific heats of different simple gases are approximately in the inverse ratio of their relative densities, the temperature and pressure remaining the same. That is to say, a gas whose atoms are twice as heavy (or twice as large, according to our theory) will require for heating a gramme of it, through 1 deg., half the quantity of heat that a gramme of gas composed of atoms of half the weight will require for the same purpose.

The weight (1 gramme) of both gases being the same, the same amount of æther will be displaced in both cases; but a gramme of the denser gas will occupy only half the space occupied by a gramme of the lighter gas. Consequently, with equal resistance, the volume of æther will in the case of the denser gas be half the volume of it in the case of the lighter. Hence the quantity of heat required to raise the gramme of the heavier gas through one degree will be half that required by the gramme of the lighter gas. Here, again, it is evident that, according to our theory, no account is taken of the fact that the proportion of displaced æther to non-displaced becomes altered as the density alters. With this qualification, it evidently follows that the quantity of heat required to raise a given volume of gas through a degree of temperature is the same whatever be the nature or density of the gas, the temperature and pressure being the same.

Assuming, as we do, that equal volumes of all gases at the same temperature and pressure contain the same number of atoms (or molecules), it follows similarly that all atoms require equal amounts of heat to raise them through 1 deg. of temperature, if the temperature and pressure is the same. This probably amounts to saying that the size of the atoms may be neglected in so far as displacement of æther goes. The fact actually observed—namely, that the above laws are accurate only in the case of extremely rare gases—directly follows from our theory, as also does the fact that the laws become quite inaccurate when we come to liquids and solids, although their influence still continues, subject to increasingly important modifications.

The second of the above laws may also be expressed by saying that when compared at the same temperature and pressure, all simple gases have (approximately) the same thermal capacity per unit volume, the "thermal capacity" signifying the product obtained by multiplying the specific heat by the density.

The above laws amount to a statement that the heat required to raise unit volume of æther through one degree is not affected appreciably by the size of the contained atoms while they remain quite dissociated, but is affected by the pressure to which they are subjected. In fact, our original definition, which makes the weight of an atom synonymous with the volume of æther it displaces, would seem to involve the above results of necessity.

It is found, also, that if equal quantities of heat are added successively to a gas, at constant pressure, the volume of the gas will increase in arithmetical progression, or, if equal quantities of heat be successively added to a gas at constant volume, the pressure will increase in arithmetical progression. For almost pure æther this result should be quite accurate, and, as might be expected according to our theory, it is only approximately so in the cases of some gases. Dulong and Petit remarked that the heats of elementary substances are, for the most part, in the inverse ratio (approximately) of their atomic weights, or that the product of the specific heat and atomic weights is approximately constant. At ordinary temperatures this is found to be a very rough constancy, though at very high temperatures it is probably nearly exact. The remarks already made in regard to the density of gases apply equally in the present instance. Many solid bodies when heated sufficiently become liquid, or melt, the melting point, or temperature of fusion, being pretty constant for each substance, under ordinary conditions. Some bodies, however, cannot be liquefied by any means at present available. Among elementary bodies charcoal is a notable example of unliquefiable substances, and this circumstance affords further evidence that there must be a peculiarity in the shape of the carbon atom, such as has been suggested. From the point of view of our theory, it is easy to see that a shape such as a cubic one would make an atom very ready to adhere firmly to others of the same kind until quite shaken free from them, and so reduced to the gaseous state. The majority of atoms or molecules with varied shapes would, however, be likely, *a priori*, to pass through a stage in which they would adhere, in a loose and shifting fashion, in larger or smaller aggregations, until they become solid, on the one side, or gaseous and dissociated on the other, and this intermediate stage is the stage of liquidity. The change from the solid state to the liquid state absorbs heat, since the stationary molecules toppling over into the æther necessarily take up heat refractions equal to those which were set free when the molecules were brought to rest in their solid positions. As a rule, when a certain temperature is reached, the change from the solid to the liquid state takes place without any intervening condition, but in the case of some bodies there is an intervening viscous or pasty state. Glass affords an example of this intermediate state. According to our theory this intermediate condition might be explained by supposing the adhering surfaces to be loosened enough to allow sliding of one particle on another without its becoming actually loose from it. In any case, these changes from solid to liquid, and from liquid to gas, are quite what might be anticipated under the conditions which our theory assumes, even though the exact mechanism of the process may be somewhat difficult to define precisely. Energy is required to separate molecules in the liquid form, sufficiently to render them gaseous and, therefore, when this is effected by the agency of heat vibrations, these latter are more or less used up or rendered "latent" in the process. We have explained that the solid state differs from the liquid in that the particles or molecules are at rest in the solid, except at the surface, where there is friction which may displace some of them. In liquids the particles move upon one another with greater or less freedom according to the nature of the liquid, that is, according to the adhesiveness of its component molecules. When we come to the gaseous state, we have a quite new phenomenon. In solids and liquids we find substances carried down by the æthereal current of gravitation as far towards the centre of the terrestrial whirl (*i.e.*, the centre of the earth) as is permitted by the solid or liquid bodies intervening. With gases this is only partially so. The molecules of a gas pass upwards against the æthereal current of gravitation quite freely. How does our theory explain this? Simply by the fact that the heat vibrations now impart to the molecules a momentum which overcomes the force of gravity. The heat pitches the molecules out against the action of gravity while tearing them apart from the molecules to which they are adherent. If, then, we cool the gas, and so diminish the force of the heat vibrations, the force of the æthereal current of gravity again bears them down, and fixes them by the excess of external pressure to the molecules which are hindered by some obstacle from proceeding further in the course of the æthereal current of gravity. In this way the present theory gives a simple and reasonable explanation of the nature of the solid, liquid and gaseous states of matter, without assuming anything more than we assumed at first—viz., an æthereal current producing gravity by its action on particles impervious to the æther, with various vibrations and subordinate movements taking place in the æther as it flows in its onward course.

In connection with the subject of liquefaction of gases, we ought not to pass over unexplained what is called the "critical temperature" of a gas. The "critical temperature" of a gas is a temperature below which pressure is capable of producing liquefaction, but above which extreme pressure fails to produce any liquefaction. According to our theory, it is evident that pressure brings atoms and molecules into closer proximity, and so tends towards liquefaction, but it is easy to see that sufficiently powerful heat vibrations may quite prevent the adhesion of molecules essential to liquidity, no matter how closely they may be pressed together. When the heat vibrations are lowered beyond a certain point (the critical temperature), the molecules will adhere when closely enough pressed together. Conduction of heat and the relative conductivity of different substances for heat, require to be considered in this rapid review of the relation of heat phenomena to æther. In the case of conduction it is simply, according to our theory, the communicating of vibrations of particles in close contact from one to another. That such must occur is too self-evident to need discussion. We may, therefore, proceed to consider the rules governing conduction in the case of different substances, and under differing conditions. Heat vibrations are fundamentally vibrations of the æther, although, of course, any particles in the vibrating æther are made to vibrate by it. It is therefore, a natural inference that the way in which heat vibrations will travel in a solid substance, in a liquid, or in a gas, will depend in a great degree on the manner in which the æther is distributed within the solid, liquid, or gas, and on the relative positions of the particles of matter as regards one another. In pure æther what is called conduction does not exist. There we have simply what is known as "radiation," in other words the free transmission of vibrations through the æther itself. Heat vibrations can pass from æther enclosed in the interstices of solids, &c., into the pure æther, but they then cease to give any of the manifestations by which we recognise heat. Heat cannot exist so as to be recognised by our senses except in the presence of foreign particles in the æther. The same remark applies likewise to light and electricity. In all these the phenomena are dependent for their character on the distribution, in relation to one another, of the æther and of the particles of matter impervious to æther. To return to heat conduction, we have, in the case of solids, particles set in a fixed position and capable of vibrating only within very limited ranges, the interstices being filled with æther in communication with the general body of æther. It may, therefore, reasonably be assumed that the transference of heat from one part of a solid body to another part will be most rapid where the particles are arranged so as readily to vibrate in unison. Where the substance is traversed by long regular uninterrupted æthereal channels, it will necessarily, by our theory, be a good conductor ; for such vibrations as can be taken up by the æthereal tubes or spaces, and by the intervening matter being consequently in long rods or wires, will readily take up the vibrations from end to end.

Metals are good conductors of heat, and it will be observed that their structure is evidently such as to indicate the presence of long very minute channels within their substance with long wirelike arrangements of the metallic particles between them. This is especially the case with the best conductors, such as silver and copper. A very noteworthy point in regard to the conduction of heat (as well as of electricity), is the fact that various processes, which do not, of course, alter the actual composition of a body as regards its ultimate molecules or atoms, but which do (as can be proved by microscopical examination) alter the system of arrangement of the internal spaces, produce important changes in the conductivity of the body. It follows directly from our theory that amorphous bodies, with particles loosely jumbled up in confusion, must be bad conductors. This is, undoubtedly, the case. Similarly liquids must be bad conductors as a rule, and the only case in which they are likely to conduct well must be where the liquid is composed of large uniformly-shaped atoms, which allow of fairly regular channels of æther between them, or the like. This, taken as a general proposition, is certainly true. In the case of gases the particles are floating about loosely, and so do not readily transmit heat vibrations directly from one particle to the other. It is, therefore, improbable that they would conduct heat well, although they would readily permit of radiation through the body of the æther in which the gaseous particles are floating. There is every reason to believe that gases are extremely bad conductors, as our theory would lead us to expect.

Felt, eider-down, wool, &c., which contain fairly stationary little masses of air, are very bad conductors, as might be anticipated. Of all the ordinary gases hydrogen conducts the best according to results of experiments performed with tubes full of various gases or rendered vacuous. Owing to the impossibility of distinguishing clearly between conduction and radiation in this case, these results cannot be relied on altogether, however. Otherwise, it is difficult to explain this property of hydrogen. Radiation differs from conduction of heat in this, that the heat passes through an intervening medium such as air, hydrogen or heat-transparent medium of other kind without affecting the intervening substance as regards temperature. Pure æther alone is, according to our theory, heat-transparent in an absolute sense. When the heat of the sun strikes the terrestrial atmosphere some of the heat is used up in increasing the vibratory movement of the particles of air, and thereby raising their temperature, part passes through, by the æthereal spaces, until ultimately it strikes on, let us say, a brick, and it is then rapidly used up by the heat-opaque substance which has intercepted it. We might indeed speak of radiant heat as "insensible" heat but for the fact that radiant heat becomes "sensible" so soon as it strikes our own bodies, not to speak of other matter. From what has been said of radiation it will be evident that, according to our theory, a body which allows free radiation must consist of continuous masses of æther which allow the direct transmission of the æthereal vibrations. Obviously, therefore, the distinction between conduction and radiation is merely founded on the difference of the transmitting medium. It is only when we come to pure æther that what we call conduction disappears, and leaves radiation alone as a means of transference of heat. In brief, conduction is the transference of heat vibrations from solid particle to solid particle; radiation the transference of heat vibrations from æther to æther. Practically speaking they are almost inseparable, as we have not as yet any means of excluding solid particles from the ætheral fluid in spaces large enough for direct observation. Pure æther is an absolute non-conductor of heat in the sense that it allows only radiation. From this it will appear why gases are bad conductors. Air, for instance, is chiefly made up of æther with air particles floating loosely in it. The æther does not directly conduct the heat, and it is only by the occasional collisions of air particles that true conduction occurs. In fact, it becomes a sort of combined convection, conduction, and radiation when heat passes through a gas. If convection and radiation were excluded, the amount of conducted heat would be but small, in all probability. Radiant heat consists of æthereal waves, and travels at the same rate as light. As has been well said by some writers, it is not heat at all, but is a form of energy capable of being readily converted into heat. It has been proved experimentally that heat passes freely through a vacuum, and that, as it has been expressed, "a ponderable medium is not essential for the transmission of radiant heat." According to our theory, weight is simply a result of the action of moving æther on bodies of different sizes which are impermeable to æther, and therefore, in this sense, a "ponderable medium" is not essential to the transmission of heat. The æther alone is essential, but it is only when the radiant heat affects "ponderable media" that it becomes what we really call heat.

We have said enough to show that our theory is consistent with the phenomena of heat as recognised, and we need not proceed to show that it is consistent with Newton's Law of Cooling, according to which the loss of heat by a hot body is approximately proportional to the excess of the temperature of its surface over that of its immediate surrounding. This is simply a matter of the transmission of mechanical vibrations, and follows the usual laws of mechanics. Similarly, the rule that the intensity of the heat received from any source of heat varies inversely as the square of the distance is merely a mathematical deduction from the conditions to which heat is due.

The absolute identity of heat and light, apart from the wave-length or rapidity of the vibrations, &c., follows essentially from our theory, and the grounds for accepting this view can be found in any good modern text book. They need not, therefore, be recapitulated here.

The fact that some substances are transparent to radiant heat which are not transparent to light, and *vice versâ*, is as obvious, according to our theory, as that different-sized organ tubes will vibrate to one note and not to another. Similarly, in regard to absorption of heat and its diffusion, reflection, &c., the reader can indeed select for himself any recognised fact in regard to heat, and he will find that there is nothing inconsistent with the foregoing theory, and nothing, perhaps, capable of easier explanation by any other theory. We shall, therefore, leave him to do so, and allow him to judge for himself whether or not our theory is tenable in this connection.

CHAPTER V.

Light in Relation to Æther.

As with heat, so with light. The manifestations of light are too well known to require any special description.

Like heat, light is generally believed to be due fundamentally to vibrations or pulses of the æther. As has been said already, heat and light are different, not so much in kind as in degree. The vibrations, or pulses, which are summed up as heat, are slower vibrations, and more or less irregular ones. The vibrations of light are more rapid (not in rate of transmission, but in succession one to another), and they are probably vibrations in a plane perpendicular to the direction in which the light is propagated. Sensible light, at all events, is probably made up of vibrations at a right angle to the direction in which the rays are propagated. A heated body becomes luminous when the heat becomes sufficiently intense, the pulses of the heated matter and enclosed æther becoming correspondingly more rapid and obtaining the rapidity of oscillation which suffices to excite the sensation of light. In the absence of non-æthereal particles light is not sensible. Æther in a pure state cannot become luminous, but it can serve as a medium for the transmission of light. The waves or pulses emanating from the sun pass through the intervening æther without rendering it luminous in the ordinary sense. It is only when they strike clouds in the terrestrial atmosphere or other aggregations of matter that luminous effects are produced. The æther carries the vibrations, but without itself becoming luminous: vibrations of frequency too high to be seen as light are very powerful in their action on chemical compounds. From what has been said already as to the nature of chemical combination, it will be easy to understand how rapid oscillations of the æther would affect the cohesion of chemical atoms and molecules. Vibrations of frequency too low to be seen are felt as heat. The waves or pulses emanating from the sun are probably only broken up into heat, light, chemical rays, &c., when they reach the terrestrial atmosphere, just as a ray of light is only split up into colours when it strikes a prism, &c. What we see are luminous particles just as what we feel are heated particles. Radiant light, like radiant heat, is not sensible apart from its influence on non-æthereal particles. Of course, it must be remembered that radiant heat or radiant light cannot reach our sentient nerves without having come in contact with non-æthereal particles.

The "wave theory" of light is so generally accepted now that it is hardly necessary to recapitulate the grounds for believing that light is due to æthereal vibrations. We must, however, consider in what way the peculiar features of the present theory agree with experimental observations on the various phenomena presented by light.

As has been remarked, the vibrations of light appear to take place at right angles to the direction in which the rays are propagated, and it is contended that this kind of vibration, although it can occur in a solid, cannot occur in a fluid such as we maintain that æther is. According to our theory, however, light does not exist as such in pure æther. It only exists in æther containing non-æthereal particles of solid matter, which can, of course, vibrate in a direction perpendicular to the direction of the impinging rays. These solid particles in their turn may, of course, excite corresponding vibrations in the æther in which they are immersed. Let us suppose a wave or pulse from the sun to strike our atmosphere. Even if the direction of the vibration is directly in the line of the ray of radiant light as it exists in pure æther, yet when it strikes a particle of non-æthereal matter, the vibrations must be diverted in part in a direction perpendicular to the surface struck, and so an element of vibration is formed in a direction perpendicular to the direction of the ray. In producing this effect (*i.e.*, sensible light) radiant light is used up, just as radiant heat is used up in raising the temperature of a body on which it falls. We see only portion of an æthereal vibration as light, the rest of it is perceived as heat, &c.

Light, or luminosity, is capable, as much as heat, of convection, conduction, and radiation. Luminous gas or liquid conveys with it the luminosity it possesses and distributes it. A luminous solid brought into close contact with a non-luminous solid can render it luminous by conduction. Radiation is, of course, well recognised, and it is the most important mode by which light is transferred. Conducted light is so soon retarded sufficiently to destroy its luminosity that conduction of light is seldom spoken of, although it exists without doubt. Good conductors for heat are, as a rule at all events, good conductors for light. When we come to compare the power of light to pass through solid bodies in a radiant condition, we find that it is by no means the same as that of heat. Glass, for instance, is an excellent fire screen, owing to its power of stopping radiant heat, but it is very transparent to light and readily allows it to pass through. From what has been said it will be seen that according to our theory radiant light and heat are both influenced by the channels and spaces of æther in a solid, and not much by the solid particles themselves. To explain this difference, therefore, between light and heat, we must consider what are the peculiarities of the interstices filled with æther in the case of glass, &c. The way in which glass breaks gives a clue to these. The characteristic feature of the vitreous fracture indicates long straight channels in planes perpendicular to the surface of the glass and passing out through the glass. Rays of light falling on the surface of the glass pass through easily since the vibrations are perpendicular to the direction of the rays, or, in other words, coincident with the direction in which the narrow æthereal intervals extend through the substance of the glass. Heat vibrations being in no one regular plane, and requiring a wider space for their oscillating movement, are taken up by the glass particles and only transmitted to a very small degree. In general, it will be found that transparent substances owe their transparency to a regular structure such as allows vibrations, of the wave-length and character peculiar to light, to pass through by means of channels in free communication with the æther outside the solid body.

Gases are necessarily transparent, as there is abundance of free æther through which the vibrations of light can travel. Liquids, such as water, alcohol, &c., are transparent to light when at rest, but if shaken up so as to break up the continuity of the interspaces, the transparency is greatly interfered with, as might be anticipated from our theory. It must, however, be remembered that, in the case of liquids, the interspaces between the particles are capable of admitting gases, and even small solid particles, which then produce opacity and various intermediate effects as regards the transmission of light. These results support our theory, for it is most improbable that, in ordinary solutions, and still less in mere distribution of minute solid particles, the composition of the solid molecules of the liquid are in any way altered. It is into the spaces between the molecules of water that the dissolved, or suspended, particles pass, and they consequently affect the ease with which light vibrations pass through the extra-molecular æther. In discussing transparency to light, as in discussing many other points with important bearing on our theory, we are greatly hampered by the extreme scantiness of our knowledge of the shapes of the constituent atoms and molecules of different substances, and also by our ignorance of the minute structure and arrangement of the substances. We therefore limit ourselves to the broad features, in the constitution of various materials, which are well recognised. Metals have a structure in the main quite opposite to that of glass. Silver and copper, for instance, can be drawn out into long threads and cannot be broken across with a clean "vitreous fracture." There is much reason, indeed, to regard their structure as made up of long thread-like metallic processes separated by similar channels running parallel to the metallic threads. Bearing in mind the extreme minuteness of these intra-metallic channels it is easy to imagine that light vibrations, even when falling upon the extremities of them in the most favourable manner would not pass far along them without being broken up and absorbed. This is, in fact, very much what experience shows to be the case with metals. Unless beaten into the thinnest leaves metals do not transmit light appreciably. Structureless masses of particles jumbled up in confusion must necessarily be non-transparent to light, as they are to heat, according to our theory; and experience quite coincides with this anticipation. Physiologically considered the portion of light, or of heat, which affects our sensation is probably only that portion which is converted into the motion of non-æthereal particles. The heat or light, which passes through us unchanged, does not affect us; it is those vibrations of the æther which set the non-æthereal particles of our body vibrating, to the loss of vibratile energy in the æther, that affect our sensation and condition. From this it follows that our sensations are all simply sensations of movement. The difference of our senses of light, heat, hearing, and touch, depend simply on our capacity of appreciating differences in the character of the movements impressed upon us. From this view we can appreciate the difference between a bright and a dull light. If the quality of the light is the same in two cases the wave-length or rapidity of succession of the pulses is the same, but the one pulse may be stronger, that is, capable of overcoming more resistance than the other, and hence the light in the one case is stronger or brighter than in the other. This is just the same as the difference between the effects of strokes inflicted ten times to the minute with a light mallet and those of strokes at the same rate with a heavy hammer, or between the strokes of one mallet every six seconds and the simultaneous strokes of a number of mallets together at the same rate. When a ray of light falls on a solid body part of it is turned back, or reflected, in a practically unaltered condition, part is absorbed by the body and then given off again as light, and part is absorbed and con-converted into heat or other form of energy. Nothing need be said here of the portion which is reflected as radiant light, the course of which is changed according to the mathematical principles which apply under the circumstances. It is the portion which is absorbed by the body, and then given off again from the body, rendered luminous, that is of most interest in connection with the present theory. It might be inferred, with reasonable certainty, that bodies of different molecular structure would not vibrate in the same way under the influence of identical vibrations of the adjacent æther, and, therefore, that the character of the vibrations given off again to the æther by them would not be quite similar in character. Experience proves that this surmise is justified, since the colour of the emitted rays, that is, the colour of the bodies themselves, differs in character in an infinite number of degrees. Differences of colour are due to differences in wave length of the pulses of light, and the structure of the bodies determines the wave-length of the pulses wherewith the body is capable of vibrating, and which, alone, consequently, it can give forth when luminous under a definite stimulus. In speaking thus of bodies as "luminous," or light-giving, we are not using the word quite in the restricted sense in which it is usually employed. It is usual to speak of a body as luminous only when it gives forth light under the stimulus of intense heat, chemical action, electricity, or the like; but a body becomes luminous under the stimulus of light also. Under the stimulus of the sun's rays the moon and the planets become luminous. Such light is spoken of as reflected light, and part of it is simply reflected light, but part of the light is taken up by the body just as much as though it were heat, and the body, thus rendered luminous, gives off its own kind of light, just as a body heated by incident heat rays gives off again some of the heat passing into it and raising its temperature. In the case of light it is customary to speak of this portion of light as "irregularly reflected," but we might just as well call the corresponding portion of heat "irregularly-reflected" heat. In both cases the light and the heat respectively, while directly derived from the incident rays, are, nevertheless, modified by the body before being given off again. How far this modifying process depends on the channels and spaces of æther, and how far on the vibratory capacity of the molecules themselves cannot be exactly determined with our present knowledge, and we shall not go deeply into the question at present; but it leads to error if the influence of a body on light entering into it is regarded as a mere matter of turning back or turning aside the incident rays. It is well recognised that different substances possess different "specific heats," and if we are right in what we say as to substances being rendered luminous by the light they take up, then we ought to expect that different substances will possess different degrees of what we may call "specific luminosity." A definite amount of light would, we might anticipate, render one substance more luminous, the masses being equal, than it would render another substance. This undoubtedly is so, although the matter is not usually regarded from this point of view. Everyone is aware that a white body is much more visible in a feeble light than a black one, and this is looked upon purely as a matter of reflection. The indisputable alteration in the character of the light is merely put down as a result of reflection from deeper surfaces of the substance, and so on, but there is no valid reason why we should regard this emission of light from an illuminated body as differing fundamentally from the emission of heat from a heated body. In both cases, of course, the heat and light respectively are partly reflected as radiant heat and radiant light, but in part also after passing into the substance of the body, both heat and light are given off in a diffused manner to surrounding particles of æther. It is simply owing to the fact that light is so very rapidly converted from light into invisible vibrations, that we are inclined to overlook the fact that an illuminated body is rendered luminous, and that the same amount of illumination produces different degrees of luminosity according to the character and structure of the illuminated body. The different qualities of different substances in regard to their capacity of becoming luminous or "self-luminous," as it is called, as a result of heat, electricity or chemical action is, on the other hand, already recognised. Phosphorus becomes luminous, without any heating effect to speak of, as a result of chemical action. In such a case luminous vibrations are produced by the setting free of æther fixed between adherent atoms, and by the imprisoning of other portions of æther in the establishment of new combinations, as has been explained in previous pages. Any rearrangement, dissociation, or combination of the atoms or molecules of chemical substances may give rise to light, or heat, when the conditions are suitable. There is no reason, however, according to our theory, why a chemical element should not give rise to light or heat by rearrangement, &c., of its atoms, without at all altering its chemical composition. There is, therefore, nothing subversive of natural laws as at present recognised in the phenomena displayed by radium. We have only by our theory to suppose a progressive alteration of molecular structure giving rise to heat, light, &c. The enormous amount of energy that may arise from alterations of the disposition of molecules and atoms, with consequent movements of æther resulting in heat, light, &c., is evident from the commonly observed effects of ordinary chemical action. As a rule the production of light is associated with much heat; but some substances are capable of emitting light without attaining any high temperature. This is quite what might be inferred from the analogy of sound, in regard to which it is well known that certain substances take up special vibrations with special readiness, the size, shape, structure, &c., of the vibrating body being determining factors. Moreover, similar selective powers have been proved in the case of heat.

The different degrees of capacity for producing light is shown in the case of ordinary flames, in which the most luminous part is not the hottest. Again, some very hot flames are almost non-luminous, owing to the want of particles of matter capable of luminous vibrations. Air, which is capable of giving out much heat, is extremely devoid of light-giving qualities. As with heat, so with light, substances which readily absorb light are in general ready to produce light freely when heated. Thus soot, which absorbs so abundantly any light falling on it, becomes very luminous, when heated in the flame of a candle. We need not, indeed multiply analogies between light and heat, because it is already evident from our theory that light and heat are fundamentally similar; that, in fact, light vibrations are only specialised heat vibrations, just as sound vibrations of the air are only specialised vibratory movements of the air. All vibrations of the air not capable of affecting our hearing, neither are all vibrations of the æther capable of affecting our sight.

A current of air striking against a fixed wire makes it emit musical sounds while it whirls along a loose feather, and colliding with various obstacles gives rise to innumerable vibratory movements, many of which can be felt by sentient beings, and some of which can be heard as noises. Sound vibrations differ as much and no more from other vibrations of the air as light and heat vibrations differ from other vibrations of the æther. The current of flowing æther striking fixed bodies capable of vibrating with luminous vibrations can and does produce light, while it carries on with it, by what is called the force of gravity, the loose bodies floating in it, and as it collides with various obstacles it produces innumerable other vibrations, many of which can be perceived by sentient beings as heat. Light is, therefore, distinguished from heat merely by the fact that the vibrations called light can affect our sight, while those of heat cannot do so. It is only certain vibrations of the air that affect our hearing, but apart from this they differ from other aerial vibrations merely in degree. Bacon has been much ridiculed because he thought of working out the nature of heat by comparing the different things giving rise to that sensation. What, his critics say derisively, is there in common between the heat caused by pepper or mustard in the mouth and the heat of hot water? Perhaps there is much in common. Though the causes be far from similar, it is quite likely that the vibratory movements of our tissues are much the same in both cases, and hence give rise to similar sensations. In any case it must be remembered that it is ultimately in the effect upon our sentient organs that the grounds for distinctions such as that between heat and light must be sought, and it must be remembered that the fact of our sense of sight or hearing ceasing to be capable of perceiving a vibratory movement does not imply that there is any very fundamental change in the character of the vibration. An organ of sense might be capable of distinguishing a vibration of 1,000 pulses to the second, and not one of 999, and the resulting difference would be enormous to the sentient being, although apart from sensibility the difference is quite trivial. The difference between light and heat is probably quite trivial at their point of contact. Indeed the quivering of the air, with its dust, around the margin of the flames of a bonfire is probably an evidence by sight of the insensible transition from light to heat. We thus have vibrations of low frequency commencing from the absolute zero which signifies absence of vibration in the æther, and vibrations gradually increasing in frequency up to the point where luminous vibrations come in, not for the most part taking the place of heat, but constituting a special part of it, and capable of being separated from it. Later on we come to vibrations of such frequency that they become again imperceptible to the eyes though capable of recognition by chemical or other effects. All these vibrations of the æther become perceptible to us by their effect on non-æthereal particles, either directly, by radiation, on particles of our bodies, or indirectly, by first communicating vibrations to external particles, and, through these, to our bodily structures. It is obvious that vibrations of æther, when they pass from pure æther into æther intermingled with particles of non-æthereal matter, will be obstructed in their course; and it cannot fail but that deviation in the direction in which the vibrations are propagated will arise in consequence. This applies, of course, to all æthereal vibrations, but it is best observed in the case of those vibrations which are perceptible by our sight, that is, in the case of light. Light passing through air or gases is easily proved to be bent away from the straight line in which it is propagated through pure æther, but it is still more bent aside when it passes through denser substances such as water or glass. We have already shown that it follows from our theory that a denser body contains in a given volume less æther than a less dense one, and hence the obstruction to vibrations of the æther is greater in the denser body, under equal conditions, than in the less dense. The greater resistance naturally produces a greater deflection of the vibrations from their original course, and so denser bodies have a greater power of refraction, a higher refractive index than the less dense. It is evident, however, that the resistance will depend, not only on the combined bulk of the obstructing matter, but also on its mode of arrangement. The effect of a solid pile of bricks on a set of sound waves would not be the same as that of the same number of bricks built with pigeon-hole apertures between them. Similarly, the channels or spaces filled with æther must influence the refraction of light by their character and arrangement, even though, in a given volume, the actual space filled by non-æthereal matter is the same in two different substances. Our theory, therefore, seems to require that refraction of light should not depend solely on the density of the refracting substance, and experiment supports this deduction. Here, again, however, as so often in discussing this theory, we are met with the difficulty that the structural arrangement of even the simplest elements is almost unknown, and the investigation of it has barely been attempted. Quite recently, however, attempts have been made in this direction, and the results, although as yet very crude, nevertheless afford to the discerning eye glimpses of great possibilities, and of important progress in the advancement of science, when the subject is dealt with in a thorough and systematic manner.

When light is split up into rays of different wave-length within the limits which are consistent with the production of the fundamental characteristics of light, a difference is found in the extent to which the rays of different wave-length are refracted by a particular substance (or by the same substance in the case of certain crystals, &c.) in different directions. The red rays being of longest wave-length are least refracted, and the violet being of shortest wave-length are most refracted in passing through a substance such as ordinary glass. In passing through Iceland spar the effect upon light of the same wave-length is different according to the direction which it takes through the crystal. In all such cases the explanation is to be found in the influence of the æthereal channels in the transparent medium or the vibrations as they pass through. When slices are cut from the mineral tourmaline parallel to its axis it is found that two of these slices, which separately are semi-transparent, become opaque when laid one on the other in a particular position—namely, at right angles—to their natural position in the crystal. This phenomenon of "polarisation," as it is called, is due to the æthereal channels in the tourmaline allowing only vibrations in one plane to pass through. When a similar slice is laid on at right angles to the first slice, the position of the æthereal channels being shifted through a right-angle, vibrations in the plane in which the transmitted rays are vibrating becomes impossible and the rays are stopped.

This, though not strictly comparable, is much as though a current of water were poured through a plate with a vertical narrow slit in it. If a similar plate be laid on it with the slit superposed vertically, the water will pass through as before, but if the second plate be laid on with the slit at right angles—that is, horizontally—the current will be practically stopped. This phenomenon of "polarisation" is therefore a clear proof of the truth of the theory that light is transmitted by æthereal channels through transparent substances. From the character of the crystals the nature of these channels may be inferred, and the peculiarity of the thin æthereal layers, which allow vibration only in the plane in which they lie, can be pretty certainly established. It has been proved that similar polarisation of heat rays can be obtained, and this again goes to prove the fundamental identity of heat and light. The phenomenon of "interference" of light, whereby it is shown that light vibrations can be brought into collision, like any other vibrations, and many other phenomena, which may be found described in works on optics, need not be detailed or discussed here. Our object is merely to show that light, as well as heat, consists of a special kind of vibrations, or pulses, in a fluid æther, and that the various changes and modifications which light undergoes are simply the result of the interposition of particles, and masses of particles, in the path of these vibrations, whereby the vibrations are absorbed from the æther through the communication of the vibrations to the non-æthereal particles, or repulsed or diverted from their path, or modified by the restrictions of enclosed tubes, layers or irregular spaces, and, in fine, subjected to all the various modifications which can be brought about in such vibrations by means of material impervious to the fluid which is the carrier of the vibrations. Enough has been said to show that the main facts that have been ascertained in reference to light might with much probability be attributed to the varied arrangement relatively of the æther and non-æthereal matter, and to the natural effect of this on vibrations such as are now generally believed to be the essential feature of luminous manifestations. Mathematicians can, when the necessary data are available, subject such surmises to critical tests.

In the meantime it is all we claim if it is admitted that, granted what we know, and a little more that we venture to imagine by reasoning from analogy and by other indirect methods, our present theory explains, better than any other, the things that we learn by means of senses which are capable of giving extreme importance to the capacity of external matter to excite certain well-defined sensations. The present theory tends in no way to revolutionise the accepted deductions from the wave theory of light. It merely alters somewhat the conceptions commonly prevalent as to the nature of æther, and lays stress on the important part played by non-æthereal matter in altering and modifying the vibrations of the æther.

CHAPTER VI.

Electricity and Magnetism in Relation to Æther.

In previous chapters we have tried to show (1) that the flow of æther through space, by its action on non-æthereal matter which displaces it and offers resistance to it, affords an explanation of the movements of the heavenly bodies and of the earth, and supplies a rational cause for the mysterious force of gravity; (2) that chemical combination consists fundamentally in the adherence of non-æthereal particles, owing to the outside æther pressing them together with force greater than that of any æther fixed between the adhering particles; (3) that heat and light comprise the various vibrations which are imparted to the æther and are transmitted through it.

It will now at once occur to an intelligent reader that if æther is, as we assume it to be, of the nature of a gas, acting as though composed of very extremely minute particles, we should expect to find differences in the pressure of the æther and very important resulting consequences. We have, indeed, already accepted the view that there are such differences of pressure, for this would necessarily follow from many of the circumstances connected with phenomena already discussed.

The supposition of æther flowing along, and interrupted by obstacles, presupposes a lowering of pressure in portions of the æther as compared with other portions, and so on, if æther is indeed of a gaseous nature. Now, we propose to put forward the movements and differences of pressure of the æther as the foundation of magnetic and electrical phenomena. Such differences of pressure, and such movements, of course, give rise secondarily to vibrations of the æther, some of which are such as to be manifested as light, and some as heat. They give rise also to special movements and changes in non-æthereal substances in ways which will be explained later on. Electricity and magnetism together might almost be defined as energy exerted through the medium of æther, but this definition would include, light, heat, &c. Some modern writers have striven to explain electricity as abstract energy. That is as though one explained the results of the blow of a stick as a manifestation of abstract energy, ignoring the stick which constitutes the vehicle of the energy. Electricity is energy, according to our theory, but it is energy conveyed through the æther as a vehicle.

The flow of æther, to which we attribute the movements of the planets, the force of gravity, &c., should, from what has been said above, be of the nature of magnetism or electricity, but just as ordinary motion is little perceptible when we, and all around us, are moving together, so we perceive but slightly the enormous movement of the æther in which we are immersed. It is, however, to this movement of the æther that the magnetism of the earth is to be attributed, and the attraction of the earth in reference to the moon, and other heavenly bodies, in like manner.

It will, perhaps, be best to begin our discussion of the relation of Electricity and Magnetism to Æther with the electric and magnetic phenomena on which electrical science was first founded. The possibility of electrifying insulated substances by friction was one of the earliest facts observed, and we may, therefore, consider how such effects are produced before we proceed to more complicated methods of producing electricity. Rubbing a piece of amber with flannel no doubt sets the particles of the amber vibrating, and so produces heat and vibrations in the æther filling the interstices of the amber. Heat, however, is not electricity, though heat produces electricity and electricity produces heat, by the common process of alteration in the form of energy which, like matter itself, can be charged but not destroyed. Vibrations such as those produced by friction must, however, be co-existent with movement of æther and consequent alteration of the pressure of continuous portions of æthers. When the result is an increase of pressure in the æther we have what is called positive electrification, and where the result is diminished pressure of æther we have negative electrification. We, therefore, have to believe that by rubbing glass with silk the pressure of æther in the glass surface is increased, while by rubbing resin or sealing-wax with woollen material the pressure of the æther in the surface of the sealing-wax is diminished. It is no doubt difficult to understand why rubbing glass with silk should pump æther into the surface of glass, or why flannel should pump æther out of the surface of sealing-wax ; but there is nothing incredible in such suppositions, and there is no simpler or more probable way of explaining the admitted fact that silk does produce electricity in glass, and flannel does produce negative electricity in sealing-wax. It would be possible to give reasons, founded on the minute structure of these bodies, showing why such results must follow ; but in the present state of our knowledge they would likely be very unconvincing. We will, therefore, adopt the plan of assuming that a state of negative electrification indicates a relatively lower pressure of æther, and a state of positive electrification a relatively higher pressure of æther, and examining whether or not the recognised facts of electrical science will harmonise with such a view.

The electric current, according to this theory, is necessarily a simple current of æther from a region of higher pressure to a region of lower pressure. If our fundamental theory of the æther is correct, it follows that the conditions, to which we attribute electricity and electrical currents, must arise ; and therefore we are making no arbitrary foundation for this attempt to explain the nature of electricity and magnetism.

If the innumerable facts discovered by electricians are capable, in the main, of explanation by means of these simple assumptions, as we believe they are, then the probability in favour of a theory capable of giving a consistent basis for the phenomena of the universe from gravitation to electricity and magnetism, can hardly be a mere fancy of an ill-balanced imagination. And even though our feeble efforts to establish the theory, for which we are here contending, may fail to carry complete conviction, yet if only an incomplete *primâ facie* justification for further inquiry be established, it may be that abler intellects will hereafter succeed in proving more conclusively that there is a solid ground for the strong faith that is in the Author of this little work, full of errors and misconceptions as such a work is sure to be.

The first essential of an electrified body, if our theory is right, must be that it has a power of exercising restraint on the movement of æther. It could not be that a charge of electricity could exist in a free mass of æther, otherwise than momentarily, without a current being set up from the region of higher pressure to that of lower pressure. When, however, the æther is mixed with foreign particles and solid matter it is evident that there may be differences of pressure in the æther surrounding the earth, just as much as there undoubtedly are in the atmosphere of the earth. The phenomenon of lightning is the resulting rush of æther tending to equalise ætheric pressure, just as a storm of wind is a rush of air tending to equalise the atmospheric pressure as measured by the barometer. The effect of lightning in tearing to pieces non-conducting material in its path is only what would be expected from what has been said as to the distribution of æther through the substance of solid bodies, and as to its pressure being the means by which even the structure of chemical compounds is maintained. A good conductor, such as a lightning conductor, supplies a set of tubes by which the flow of æther takes place without much hindrance from one end of the rod to the other. If too strong a rush of æther takes place through such conducting tubes they are burst up, and are fused by the resulting heat. The rush of æther in the lightning of course sets up vibrations, some of which appear as light, and some of which produce the usual effects of heat. The dashing about of the non-ætheric matter which resists the electric current produces the roar of the thunder, much as the wind makes a roaring sound as it passes through the trees, or the torrent of water as it dashes on the rocks or washes up and down tons of pebbles and sand on the sea-shore. But before the lightning current flashes forth, there has been a highly-electrified mass of air or clouds wherein the pressure of the æther has been higher than that of the air or ground in its vicinity.

For all practical purposes this may be regarded as similar to the condition of the glass electrified by friction with silk. By some means the friction of the air or of particles of water or of snow has pumped up the pressure of æther in one part and necessarily lowered it to a corresponding degree elsewhere. The sealing-wax rubbed with flannel has the æther pumped out and the pressure lowered in the rubbed surface, while the glass rubbed with silk has the æther pumped out of the surface and its pressure raised. This is no more inconceivable than the condensation of gases, such as air, in certain substances. Indeed air itself is undoubtedly imprisoned in a peculiar way amid the fibres of wool. While, however, it may be admitted that the mechanism, by which this raising and lowering of the pressure of the æther is effected, seems obscure, the fact that change of pressure occurs appears to be clear enough. This kind of electrification takes place only in non-conducting material simply because, in a good conductor, the æther would at once flow from the region of higher pressure to the region of lower pressure, and equilibrium would result. Bearing in mind the continuity of æther throughout space, it follows that any movement of æther will produce vibrations passing through the æther. If the æther is free and unconfined such vibrations pass out in all directions into the general mass of æther, and soon become dissipated, converted into heat, &c. But in the case of æther confined in the minute tubes of, say, a metallic wire, the resulting vibrations pass along these tubes for enormous distances with but little loss of energy, and the æthereal vibrations are easily detected at distant sections of the wire. These vibrations probably differ from those of light in that they are in the same plane as the direction in which they are propagated, and not like light in a plane perpendicular to the line of propagation. In this way the minute tubes of the electric wire act in a manner quite analogous to the action of a speaking tube in conveying the coarse ærial vibrations of ordinary sound. Thus, although electricity consists, in the main, in a current of æther producing an actual movement of æther from one place to another, yet many of the important and familiar phenomena of electricity no doubt arise from vibrations in the æther which are not recognised as heat and not recognised as light. When these electrical vibrations are taken up by non-æthereal particles they give rise to light, or give rise to heat. They can also by various devices, well known to electricians, be converted into simple motion of non-æthereal substances, as in the telegraph, telephone, &c.

We need not delay to explain how a conductor affords channels by which the æther flows away, and hence discharges the electricity, or how the æther may be drained off at high pressure into the æthereal channels of a conductor thereby electrifying it, if it is well insulated, and so on. These phenomena follow obviously from the conditions assumed. The phenomena of induction and those of the repulsion between similarly electrified bodies and also the attraction between differently electrified bodies, require some explanation, however. If an electrified glass ball is placed near the end of a sausage-shaped piece of metal, insulated on a glass support, the end of the metal cylinder next the glass ball becomes electrified with negative electricity while the end furthest away is electrified with positive electricity. The explanation of this would seem to be that the electricity at high pressure in the glass ball is under a strain urging it, and to a small degree carrying it away, to regions of lower pressure. This pressure is exerted through the æther between the ball and cylinder, and urges the æther along the channels of the cylinder. By this pressure the æther is subjected to higher pressure at the remote end of the cylinder where the transference of the force or strain is blocked, and the pressure at the near end of the cylinder is proportionately lowered. If the remote end of the cylinder is connected with the earth the æther is driven out at the remote end, and only the lowered pressure is manifested as negative electrification. This may be compared roughly to a vessel full of water or gas under pressure, with small tubes opening into the vessel. If the tubes are open at the remote end the pressure at the entrance to the tubes will be lower than in the mass of the liquid or gas, else it would not flow through. If, however, the tubes are partially closed at the remote end the pressure will still be lower at the entrance of the tubes than in the adjoining mass of liquid or gas, but the pressure at the remote ends will in this case be higher than that of the liquid or gas free outside the ends of the tubes. Consequently we have a negative pressure in the near ends of the tubes as compared with the positive pressure around them, and a positive pressure in the remote ends of the tubes as compared with the negative pressure around and outside them. When the outer ends of the tubes discharge freely the difference between the pressure just inside and just outside the tubes becomes trivial. If an electrified piece of sealing-wax negatively electrified is similarly brought near a metal cylinder the end of the cylinder near the sealing-wax is positively electrified. In this case the æther within the tubes of the cylinder tends to flow towards the lower pressure of the negatively electrified sealing-wax, and the pressure inside the near end of the cylinder is consequently higher relatively than that in the æther outside the cylinder.

This difference of the pressure at the near end of the cylinder draws the æther away from the far end, and the æther tends to flow into the far end from the outer air. The pressure inside the remote end of the cylinder is consequently lower than that outside it. This explanation does not necessarily require that there should be an actual flow of æther from the region of lower pressure to the region of higher pressure, though, no doubt, there always is a little leakage, although the insulating air offers great resistance to the flow unless the difference of pressure becomes great enough to burst through, producing the familiar spark.

It must be remembered that, according to our theory, these phenomena of electricity depend on the relative pressure of æther. Thus a body positively electrified in reference to a body in which the æther is at lower pressure would, for all practical purposes, be negatively electrified in reference to a body in which the æther is at a higher pressure than the æther within itself.

We must next consider how it is that a positively electrified body attracts another body similarly electrified. Let us take, for instance, two pith balls. Here, if the electrification is positive, we have the æther in both balls at higher pressure than it is in the intervening space. Consequently, two opposing currents tend to run in exactly opposite directions, and the current from each pith ball tends to drive the other away. In the case of negatively electrified pith balls the currents from the intervening space tend to run into each pith ball and so bear them away one from the other.

As this theory of electricity, though not postulating any special electrical fluid, is practically similar in its consequences to Franklin's "one-fluid theory" of electricity, it is worth while to notice some of the arguments against the one-fluid theory, such as are mentioned in elementary treatises, and do not necessarily involve any abstruse mathematical calculations, for we are, in this little work, avoiding as much as possible any line of argument which cannot be understood by anyone who is intelligently acquainted with the natural phenomena involved.

In Prof. Silvanus Thompson's excellent little elementary lessons in Electricity and Magnetism (1882) we read :—" It is, however, quite certain that *electricity is not a material fluid*, whatever else it may be. For while it resembles a fluid in its property of apparently flowing from one point to another, it differs from every known fluid in almost every other respect. It possesses no weight : it repels itself." We have here an excellent example of the kind of fallacy which may arise through the attaching of wrong ideas to particular words. If by "material" we mean *non-œthereal*, then electricity is certainly not a "material" fluid, if we are right. But if by "material" we mean *capable of occupying space to the exclusion of other forms of matter* then our contention is that the fluid which gives rise to electrical phenomena is "material." Again, if by "weight" we mean a power of attracting, or being attracted by, other kinds of matter, then we contend not only that æther has no weight, but further that no form of matter has of itself any weight in this sense of the word. If by weight we mean, however, an impetus towards the centre of the earth, or towards the centre of any body which obstructs the flow of the æther, then we contend that æther has weight, and that, in fact, it is the æther which communicates to other forms of matter the impetus which we call weight, in the manner which has been already outlined in our earlier pages. The fluid which we believe to give rise to electrical phenomena, that is, æther, does not indeed repel itself of itself ; but æther moving in one direction does repel æther at rest or moving in a contrary direction just as any ordinary material fluid does, be it liquid or gaseous. These objections, therefore, fall to the ground as arguments against the theory that electricity is due to conditions present in a material fluid—viz., æther—if our theory as to the nature and properties of æther, and as to its relation to other forms of matter, is tenable. We have already noted the fact that substances that are good conductors of heat are not always good conductors of light, and *vice versa* ; and now, again, we find that good conductors of electricity are not always good conductors of light and heat, and *vice versa.* In regard to light and heat, we had to deal with the conduction of vibrations, and we attempted to show that the difference in the character of the vibrations accounted for the difference in the conduction, just as there is a difference in the conduction of sounds due to differences in the character of the sound vibrations and of the channels, &c., conducting those vibrations. In the case of electricity, however, it is a matter of greater or less resistance to currents of the æther in the first place, and only in a secondary way a matter of the conduction of vibrations. It is, consequently, easy to perceive that there will be cases in which the flow of the æther is powerfully inhibited, while at the same time there is little hindrance to the transference of suitable vibrations through the æther whose flow is subject to powerful resistance. It is, therefore, no very fatal objection to our theory that glass, for instance, readily transmits light, and yet offers great resistance to the passage of electric currents. Dry air, again, is a very bad conductor of electricity, yet it is very transparent to light and to heat. Water, on the other hand, conducts electricity fairly well and conducts heat remarkably little. We do not, at present, attempt to give any clear explanation why these differences exist, but we maintain that such diversities are no disproof of the truth of our theory. With fuller knowledge of the intimate structure of various substances, it seems reasonable to expect that confirmation of our theory will be forthcoming, and in the meantime, we may content ourselves with showing that such differences of conducting power may easily occur without involving any necessary inconsistencies. At first sight it seems strange that air, which apparently must contain much free æther amongst its floating particles, is yet a very bad conductor of electricity. When, however, we remember what a marvellous power air has of penetrating into the substance of water and even of solids of very dense structure, it is easy to imagine that particles or molecules of air may plug up very effectually the minute channels by which alone the æther can flow in and out of an electrified body. Take, for instance, the free end of a highly-electrified copper wire in air, is it not possible, nay probable, that air particles are crowded into the orifices of the minute æthereal channels in the copper, and that they require to be broken up into their component atoms before they can be effectually cleared out and the consequent plugging of the æthereal channels removed?

If we regard electric potential as æthereal pressure, it needs no explanation when we find that a definite quantity of electricity communicated to a large constructor imparts to it a proportionately lower potential than the same quantity of electricity would impart to a smaller conductor of the same material; and therefore of capacity proportionate to its size. This is as though we said that if a conductor holds half a pint of æther, a similar conductor of twice the size will hold a pint of æther at the same pressure.

The effect of pointed conductors in facilitating the discharge of electricity is analogous to the result of narrowing wider tubes of water, under pressure, at their extremities. The discharge becomes more forcible and overcomes resistance which would otherwise have prevented discharge. The fact that the electric spark is obtained more readily from a point on an electrified conductor is, indeed, quite suggestive of the idea that an electrified conductor contains æther under pressure, and that the æther escapes most readily from a pointed exit. The nature of the discharge can be rendered evident to the sight by holding a lighted taper near the end of a sharp point connected with an electrified conductor. The outward flow of electricity blows the flame to one side as the rush of æther sweeps forward the air or other particles in its way.

We have spoken of the production of electrical conditions by friction; but it has been proved that substances may be rendered electrical by violent blows, by setting up vibrations, by tearing or splitting, by the changes due to crystallisation and solidification, by combustion, evaporation, pressure, heat, &c. It will be unnecessary to explain each of these in detail, as it can readily be seen from what has been said that all the above tend to alter the relative position of the particles of the substances, and so, of course, to loosen or compress the enclosed æther. It is, therefore, what might be expected, that alterations in the pressure of inter- or intramolecular æther would result, and according to our theory such alterations would involve the development of electrical conditions. It is also worthy of note in this connection that tourmaline and several other substances which by their action in regard to light show peculiar arrangements of the æther within them, likewise exhibit special electrical properties. The full discussion of such properties cannot be entered on here, but it is obvious that our theory of electricity suggests probable reasons for such electrical peculiarities.

The difference of electrical potential between dissimilar substances, or between pieces of the same substance at different temperatures, can also be very simply attributed to difference in the pressure of the æther in the ætheric channels and spaces of the substances such as would be sure to arise if our theory is true. Our explanation of the nature of chemical combination makes it certain that electrical conditions can be produced to a very high degree by chemical changes, since the theory attributes the adherence of the atoms, &c., in chemical compounds to difference in pressure of the æther between and outside the adherent atoms, and so on. As regards the effect of the electric current in displacing atoms from combination, that also necessarily follows from our theory, but we shall speak of the phenomena of electrolysis, as it is called, more fully a little later on. The production of electricity by the agency of magnets is, however, an all-important method of exciting electrical conditions, and it is consequently desirable to discuss its origin before proceeding further.

It is not, at first sight, at all so easy to see how magnetism can be explained by movements of the æther, or differences of pressure in it, as it is in the case of frictional, chemical or thermal sources of electricity. We shall, therefore, begin with the simple magnet and try to show how its marvellous properties can be explained without assuming the existence of anything more than the fluid æther, and the non-æthereal particles of matter bearing to one another the simple relations which we have from the first assumed to exist. The power, possessed by a lodestone or magnet, of attracting iron or steel, seems at first quite different from all other natural agencies. Without any apparent motion in itself the magnet imparts motion. There appears to be a power of attraction not exerted through any material medium, a power of attraction such as we have from the first denounced as grossly improbable, and at variance with all that we observe throughout nature. We have no reason to suppose any condition of vibration in the particles of the magnet such as might impart movements to the surrounding æther. There is nothing to suggest that the magnet can itself originate movement in the æther. We are consequently led to ask ourselves if it may not be that the magnet in some way modifies the movement of the æther to which we have attributed the movement of the planets, and the action of gravity. This is a possible source of energy which can be supposed to produce important results without its powers being altered or diminished. Merely stroking a piece of steel with a magnet cannot be imagined to transfer permanent power of lifting iron against gravity by any transference of energy. The magnet loses no power by imparting power to the steel which it magnetises. But here we have a bit of steel without magnetic power suddenly endowed with magnetic power. In order to arrive at the nature of magnetism, therefore, we cannot do better than find out in what it is that the magnetic steel differs from the steel before magnetisation. To outward appearance the steel is unchanged. It weighs the same after magnetisation that it weighed before. It has undergone no chemical change in the ordinary sense of that expression. When a steel bar is strongly magnetised, it grows a little longer than before, and a little less thick. A faint metallic click is heard in a bar when it is magnetised. Various experiments with filings, &c., strengthen the idea that is suggested by the above facts—namely, that the particles or molecules of the steel change their position and set themselves in a new position in the magnetised bar. Numerous experiments, which need not be detailed, have practically proved that such re-arrangement of the particles of the iron does take place when a bar is magnetised. Rough usage of a steel magnet, violent blows, extreme heat, &c., destroy its magnetic power. The properties in regard to light and the conduction of electricity or heat, &c., are affected by magnetisation, in such a way as to imply, according to our theory, an alteration of the internal arrangement of the æthereal channels and spaces. We are, therefore, justified in assuming that magnetisation causes a rearrangement of the particles of the magnet, and that the particles of a steel magnet are set in some definite structural position in the bar Since some such change is the only one which can be observed in the physical condition of a magnetised bar when compared with the same bar unmagnetised, we ought to consider very carefully whether or not such a change could in any rational manner account for the production of the magnetic power. If we accept the view already propounded, that there is a rapid, continuous flow of the general mass of æther, is it not possible that the arrangement of the particles in a magnet may be such as to impart to the current of æther a peculiar movement, not as in the case of light or heat—vibratory, but let us say a rotatory or whirling movement ? A twisted pipe laid in the line of a current of water and totally immersed, gives an example of the kind of effect to which we allude. The earth, according to our theory, generates a large whirl in the general body of the æther, and the earth is apparently itself a large magnet. May not a magnetic needle generate a little æthereal whirl by the peculiar arrangement of its tubes, which allow passage to the æther, and so on a small scale produce a result of a similar character to that produced by the earth? A steel bar held in the magnetic meridian, and struck with a wooden mallet, becomes magnetic, as do steel wires twisted while in the magnetic meridian, showing that the magnetism of the earth can be used to magnetise a steel bar or wire.

If, now, magnetism is due to the normal current of æther, with a peculiar vortical movement, or strain urging to such movement, introduced by the arrangement of the tubes or channels through which the æther passes in its course through a magnet, how can we explain the poles of the magnet and the phenomena connected therewith? Evidently the conditions will be largely similar to those produced by an ordinary electric current, which we have explained as a current of æther in restricted channels and spaces. The point of higher pressure will be the positive pole and the point of lower pressure will be the negative pole, and as the current will flow or tend to flow from higher pressure to lower, the negative pole will be the part of the magnet from which the current flows, and the positive pole the part from which the current passes out. The phenomena of attraction of dissimilar poles, and repulsion of similar ones, may be explained in the same way as the attraction and repulsion of similar and dissimilar electricities. The attraction of either pole of a magnet for a piece of iron is due to the magnetising effect of the magnet on the iron, and naturally the current is induced in the same direction as the inducing current. The effect of a current of æther in causing the particles of matter to adopt certain positions is quite analogous to what is observed in the case of coarser fluids, and coarser particles; although, of course, the precise explanation of such phenomena is more or less complicated. When bars are heated strongly they can be more powerfully magnetised by the terrestrial magnet, by electromagnets, &c., and this is very probable because the heat makes the particles of the bar more mobile by the vibratory movements which it imparts. The magnetisation of a bar by an electric current carried round it is due to induced currents no doubt. If the bar is of soft iron, the particles do not remain in the position necessary to constitute magnetism, when the electric current is stopped, whereas, with hard steel, they retain their new position and produce the effect upon the normal æthereal current which is produced by the earth itself, or by a magnet of any permanent kind.

We attribute the normal magnetism of the earth, and of permanent magnets, to the normal flow of æther, and, therefore, if anything in any way affects that normal flow of æther, the magnetism of the earth, &c., should be affected. Now, when we consider all the various changes which must, according to our theory, influence the flow of the æther, marvellous though its constancy must undoubtedly be, it seems inconceivable but that there will be from time to time accelerations or retardations of the æther, trivial, of course, relatively to the entire movement, but still quite perceptible. The Aurora Borealis and the well-recognised "magnetic storms" are not only explained by our theory, but their occurrence almost necessarily follows, if our theory of magnetism and electricity is correct. We shall not, at present, attempt to show how all the facts and laws of electric, magnetic, and electromagnetic, sciences are capable of being satisfactorily explained in harmony with this theory of the nature of electricity and magnetism.

The attempt to crowd masses of obscure details into this rough sketch might likely enough render the outlines much less intelligible without giving at all a clear conception of the more minute features. We must, however, before closing this chapter review rapidly some of the very important phenomena which are classified under the title of electro-chemistry. The production of electric currents, by chemical action in the various kinds of voltaic cells, arises according to our theory from the alterations in the arrangement of the chemical atoms and molecules producing changes in the pressure of the æther. If the essence of chemical combination is, as we contend, a fixing together of atoms, &c., by the adherence of surfaces owing to a higher pressure of æther without the particles than that which exists in the æther imprisoned between the combining surfaces, then it follows that a re-arrangement of atoms, &c., will in general produce alterations in the pressure of the æther immediately adjacent to such atoms, &c., and that currents of æther will be engendered. But currents of æther, under such circumstances, are equivalent to, or identical with, electric currents. Conversely, if chemical changes give rise to electric currents, it follows that electric currents will in their turn produce, or tend to produce, chemical changes. Just as a current of water tends to disintegrate adherent lumps of matter immersed in it, so does a current of æther tend to break up chemical combinations exposed to the current. When the electric current suffices to break up a chemical compound into its constituent atoms, it is likely that some of these atoms would be carried along in the current, provided that the atoms are not too large to pass through the channels or spaces through which the æther is flowing. Experiment shows that under suitable conditions the electric current does carry along with it some of the atoms into which it splits up the chemical compounds in which its electrolytic influence is exerted. We must, therefore, consider what it is that determines the transference of one set of atoms with the current of æther, while another set resist the current or pass up against it.

When water is broken up by an electric current into hydrogen and oxygen the hydrogen is carried down to where the current leaves the liquid, while the oxygen is crowded up round the point where the current enters the liquid. The travelling atoms set free by electrolysis are called "ions." Those which go down with the current are called "kathions," and those which collect where the current enters are called "anions."

From the conditions assumed in our theory it is evident that the larger atoms—*i.e.*, those of highest atomic weight—will be more forcibly acted on by a current of æther, of the the kind regarded as an electric current, than smaller atoms. Hence, other things being equal, atoms of higher atomic weight will tend to be kathions, while atoms of lower atomic weight will tend to be anions. But we must evidently also take into account the so-called "affinity" between the atoms and the material from which the electric current enters the electrolysed fluid, since we have to consider the force propelling the atoms, and the resistance offered to their transfer, in calculating the resulting movements of the atoms. Moreover, the affinity between the atoms of the same kind, and between the atoms and unaltered molecules, as well as between the dissociated atoms of different kinds, have all to be reckoned with. Consequently the rule that the heavier atoms will be kathions, and the lighter anions, cannot be expected to be without exception. Our theory does not allow of the explanation that each atom becomes itself electrified positively at one end and negatively at the other, because we regard the atoms as impervious to æther, and therefore incapable of electrification.

In this case of electrolysed water, the oxygen is carried down with the current and the lighter hydrogen collects where the current enters. Bearing in mind the modifications to which we have alluded, the facts observed in experiments in electrolysis appear to support our hypothesis as exactly as would seem at all probable, in view of the complicated nature of the process in some instances. The fact that the ions only appear at the points of entrance and exit shows that the atoms keep on a succession of dissociations and reunions in their passage through the liquid. It is unnecessary to explain that this is quite in harmony with our view as to the nature of chemical combination. The phenomena of electromagnetism present many points quite in favour of our theory, and none that appear at all hopelessly inconsistent with it;

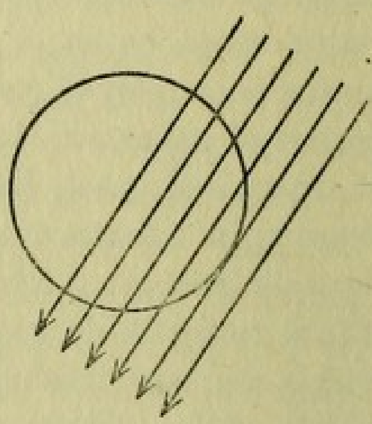
but as we do not intend here to proceed systematically through the laws and phenomena of electromagnetism it seems unnecessary to select any special examples for consideration. It is worthy of note, however, that, while a coil of wire, carrying an electric current, wound spirally round a bar of iron, magnetises it, at the same time the spiral coil itself, without the iron, acts as a magnet, showing what we contend, that the essence of magnetism is a current of æther running in a spiral fashion (or in some such way) around the line of the main direction of the current.

CHAPTER VII.

The Nature, Properties, General Characteristics and Distribution of Æther.—Conclusion.

The main idea of the nature and distribution of æther as assumed in this theory is not a new one. It has been defined as "an unponderable elastic fluid, filling space and forming the source of heat, light, electricity, &c.," in the "Dictionnaire Complet," by P. Larousse as quoted by Prof Mendeléef, in his "Attempt Towards Chemical Conception of the Ether," published in 1902. It was in 1898 that the Author of this little work published a brief sketch of the main idea set out herein, and although that tiny pamphlet never, in all probability, met the eye of Prof. Mendeléef, it was encouraging to the writer to find so eminent an authority adopting views in the main reconcileable to the theory he had ventured with some diffidence to propound. Æther, it is admitted, must be regarded as possessing properties such as might justify its being described as a gaseous fluid, composed of atoms almost indefinitely small as compared with recognised chemical atoms. One of the difficulties, which some have felt in regard to this view of the nature of æther, arises from the consideration of the question as to whether æther has what is known as weight; and, if so, to what extent. We have already dwelt on the necessity of ascertaining what weight really is before drawing final conclusions from the presence or absence of evidence of ponderability in æther. Our idea is that weight is the force communicated to material particles by the flow of a vast mass of æther, of dimensions which to us are practically unlimited. The amount of this force communicated to non-æthereal bodies depends, according to our view, on the quantity of æther displaced and on the resistance offered to the flow of the æther. In a sense, æther has weight according to this view, but it is obviously not weight in the same sense as weight when applied to non-æthereal particles. Weight, as we know, varies according to the medium in which a body is weighed. How, then, are we to weigh æther? We can only weigh it in itself with present appliances, and therefore, in the sense that water is without weight when weighed in water, so is æther without weight when weighed in æther. If we could produce an ætherless vacuum, then, weighed in this vacuum, I doubt not that æther would still be without weight, unless there is a still more æthereal medium which could impart impetus to æther, just as æther imparts impetus to ordinary matter. While, however, æther is in communication with the general body of the æther, a given volume of it receives from the main body a definite impulse which is subject to the influence of any resistance which it encounters. It is this resistance which causes differences in pressure, or in what may practically be regarded as weight, between different portions of æther. Thus, although from one point of view, a cubic metre of æther has no weight, yet from another point of view one cubic metre of æther may differ from another cubic metre of æther in weight, that is to say, in the impetus with which it tends to move in a certain direction, which varies according to the way in which the æther is flowing at a given place. Once we admit the existence of the æther as a fluid in which the universe is immersed, and with which we and all else, are more or less soaked, according to our structure, it becomes possible to appreciate the manifestations of its changing conditions by our natural senses. We cannot see the air, neither can we see the æther, but we can feel movements of the air, and we can most acutely feel movements of the æther. In fact, we are much more effected by æther than we are by air, little as we recognise it, owing to our having regarded its different effects, light, heat, electricity, gravity, &c., as things without any bond of connection. Although we cannot at present exclude æther from any appreciable space, so as to apply the tests which could by this means be employed, yet we can study all the important properties of æther, nearly, if not quite, as well as we can those of recognised gases, &c., provided that we do not persist in denying its existence because it differs in several important respects from other forms of matter. We are able to obtain it in a moderate degree of purity in the very complete vacua, which are now obtainable, although it is enclosed in vessels which, while excluding other forms of matter, allow rather free leakage, in and out, of the æthereal fluid. The discharge of an electric current into a vacuum shows the results of discharging æther into a space filled with æther. The æther discharged into the space by the minute tubes of an electric wire at one end, naturally passes out chiefly by the open tubes of a wire at the other end, rather than force its way through the glass walls of the vacuum chamber, the interstices of which do not readily allow the current to pass. The presence of impurities in a vacuum shows the effect which non-æthereal particles have in rendering the currents of æther visible by luminous vibrations of these particles. Without the presence of non-æthereal particles of matter, luminous effects cease altogether, and the phenomena characteristic of electricity in great part also disappear. This is what might be inferred from what has already been said in discussing the relations of light and electricity to æther. Æther appears to be quite inert chemically, showing no power of combining with non-æthereal elements. If our theory as to the nature of chemical combination is accurate, this must be so, as the intervention of low-pressure æther between chemical atoms, and the pressure without of higher-pressure æther, are the essential conditions of the state of chemical combination.

The velocity of the æther flowing through the interstices of the air, and of the earth, must evidently be retarded by friction. The æther which passes centrally through the earth must be more retarded than the æther which passes more near the circumference, as may be seen by the following diagram. This must lower the pressure of the æther along the central axis of the earth as compared with lines parallel to the axis.



Accordingly, we have a condition similar to what is known as a cyclone in the terrestrial atmosphere, and the result must be a whirling motion of the æther, tending to carry the æther from the region of higher velocity—that is, in the case of the æther, of higher pressure, towards the central region of lower velocity, that is, of lower pressure in the æther. This causes rotation of the earth, and produces in the æther the whirling motion to which we claim that the phenomena of magnetism are due. Hence the magnetism of the earth, as well as its rotation, are capable of explanation by the simple assumption of a flowing mass of æther enveloping the terrestrial system. We have already shown in outline how such a whirl must spread out its influence through the general mass of æther. The same applies to suns, stars, and planets, and the resulting whirls in the æther act and react.

It follows also from this view that the larger body must produce the more powerful whirl, and the smaller body the lesser one. From this many of the general laws of astronomy may be deduced. Naturally this friction between æther and non-ætheral matter produces heat, and ultimately light, and when a celestial body becomes large enough it becomes a sun. This is quite inconsistent with some generally accepted views, according to which planets are burnt out suns. It is, however, quite conceivable that the progress is in the other direction, and that a small body by a gradual process of aggregation of matter becomes larger and larger until it reaches a size sufficient to confer on it the dignity of a sun. Is there not, in fact, as much evidence to show that the earth has increased in heat as there is to show that it has grown colder; and is there any sign that the sun is losing its heat, and not rather growing hotter? Is it not quite possible that matter tends gradually to accumulate in heaps in the flood of æther, albeit from time to time particular aggregations may break up, and be dispersed and redistributed? We know that every autumn small masses of matter are regularly added to the earth; we have no evidence that similar masses ever leave it, either in the gaseous or solid form, though it may be, of course, that the moon was once terrestrial, or it may be that meteors fly off unobserved from the atmosphere of the earth, if not from the solid earth itself. The latter supposition is, however, very improbable, and the former not likely. How it comes to pass that the æther is moving through space, we shall not attempt to guess. It is no more improbable that it should be in motion, than that it should be at rest. We have very strong reasons for believing that it is in motion, and very strong reasons for disbelieving that it is at rest. If it is in motion, that motion is capable of producing all the various phenomena which are otherwise extremely inexplicable.

Matter, including æther, cannot be created or destroyed by us; neither can motion. It is by its movements that matter becomes perceptible to our senses. All our natural senses, differing so widely, as they seem to us to differ, are but powers of appreciating movements. Our eyes enable us to perceive vibratory movements imparted to matter by the æther. Light vibrations may be imparted directly to our material particles, through the mechanism of the eye, and visual apparatus, from the æther itself; and so may heat vibrations, without the aid of the eye. The ear appreciates vibrations of the air. The sense of touch reveals the movements of all coarser forms of matter in relation to the sentient parts of our bodies. The power of distinguishing the various special characters of movements is what differentiates between our various senses, and between the varying effects perceived by our senses. But, because we perceive only the movements of matter, or rather changes in the movements of matter, it cannot be argued, as some would seem to do, that movements exist without anything to move. We distinguish between the movements of air and the movements of water, just as surely as we distinguish between the movements due to light and those due to heat.

The important results which accrue from the pressure of the air on our bodies is well understood. The fatal consequences of passing into regions, where the pressure of the air is excessively diminished, have been proved by experiment. The pressure of the æther, however, is of even greater importance. Without the pressure of the æther, atom would not adhere to atom, while the earth and all in it would be without form. Weight would vanish, and there would be nothing to hold together the particles of the rocks and mountains or the cells of our own bodies. Without æther all things would crumble to dust. If the cohesion which renders possible all the structures, whether animate or inanimate, which we see in Nature, is not due to the pressure of a fluid such as æther, to what is it due? Why do two smooth plates of metal adhere firmly in a vacuum? Our theory says it is much in the same way as the hollow Magdeburgh hemispheres stick together when the air within is exhausted. In that case the air holds them together by its pressure outside exceeding that within. We say that two chemical atoms adhere, because the pressure of the æther outside exceeds that of the æther between them. This is a rational and probable explanation, strongly supported by the analogy of numerous facts in Nature. And it is ultimately on somewhat similar kinds of analogy that our belief in most of the laws of Nature depends.

If our theory is scouted and cast aside, what other theory with a shadow of probability can be proposed in its stead? We can, of course, explain facts by words. We can imagine that calling it "affinity" explains the tendency of atoms to fly together and cohere firmly. We can say that the "attraction" of the earth draws meteors to its surface. So might we say that the rocks "attract" a ship to them when it is dashed against them by the violence of the ocean. So might we say that two Magdeburgh hemispheres have an "affinity" one for the other. The elastic properties of æther resemble those of a solid rather than those of an ordinary fluid, and this has to some appeared an almost insuperable difficulty in the way of regarding æther as a gaseous body. The enormous rapidity with which light vibrations are transmitted seems to indicate that æther has qualities more like those of a solid than those of a gas. This difficulty is, however, deceptive, because æther does possess the same quality as a perfect solid, in that its particles, according to our theory, are in direct contact and not separated, as are the particles of other fluids, either by more minute particles of non-æthereal matter or at least by æther itself. There is in the nature of æther nothing to make its particles adhere to one another; no intervening fluid which is at lower pressure between the æthereal particles and at higher pressure outside them. They move with perfect freedom one upon the other. The particles are, however, in absolute contact in pure æther, and movements are transmitted in the same character in which they start.

Vibrations, such as give rise to light, are not altered into heat so long as they are transmitted through pure æther. There is nothing to reflect, or refract, the motion imparted to æther, until resistance is interposed in the form of non-æthereal particles. Regarded in this way there is nothing to be surprised at in the fact that æther displays such marvellous elasticity. In fact, such elasticity may be confidently predicted of a fluid the particles of which have nothing intervening between them. When non-æthereal particles are introduced into the æther the movements of all kinds are more or less retarded, the characters of the movements are changed and their directions altered. The elasticity of æther is an argument in favour of the idea that there is not any still more subtle fluid intervening between the particles of æther, in the same way as æther intervenes between the particles of grosser forms of matter; though it does not, perhaps, exclude that possibility, when we consider how infinitely minute the particles of such a fluid would have to be. In considering such matters, it must be remembered that, although we can conceive (or rather can fancy that we can conceive), infinite minuteness as well as infinite greatness, yet it does not follow that anything infinitely great or infinitely small exists. Indeed, it is a contradiction in terms to state the existence of any infinitely great or infinitely small thing. Nature leads us to expect limits often at quite unexpected points. Till we know otherwise, it is quite possible that a hydrogen atom is the smallest particle existing in the universe. When we know that the æther atom is smaller still, by a great deal, there is nothing absurd in supposing that the æther particle is the smallest that exists. One of the suns within the universe is no doubt the largest, or one of the largest, and one of the atoms in the universe is no doubt the smallest, or one of the smallest. Nothing, of which we can appreciate the existence, is infinite. Everything we know has a limit. There are strong reasons now for saying that smaller particles exist than those of hydrogen; but there are strong reasons for believing that the particles of æther are the smallest that exist. We can imagine smaller particles, of course, but even if we learn the precise dimensions of an æther atom it does not follow that it can be divided into two. We can imagine a sun greater than the greatest sun to be seen, but it may well be that no greater sun exists.

This needs to be kept in mind, because the abstract ideas of mathematics are sometimes dealt with as though they expressed actual entities. Æther, then, according to our theory consists of very minute particles, most probably the smallest particles that exist in our universe. Its physical properties resemble those of gases to some extent, and those of solids to some extent. The particles of pure æther move with freedom, one in contact with others. In this they resemble a perfect fluid. Non-æthereal fluids gradually approach the qualities which we may regard as characteristic of a perfect fluid, but they never attain to that perfect state because their particles are separated by æthereal, and often by much grosser, particles. In respect of such qualities as that of transmitting vibrations, solids approach more or less to homogeneity, but they never attain it. The particles are never in absolute contact. There are always æthereal or grosser particles intervening. Æther is in all probability either homogeneous, or relatively speaking homogeneous; and there is nothing intervening between its ultimate particles. Hence æther has qualities which might be ascribed to a perfect solid, or to a solid more nearly perfect than any solid that exists. We have already shown that æther must be incapable of any chemical action, if our definitions of chemical action are true. All the evidence goes to show that it is absolutely inert chemically. From a chemical point of view æther has properties entirely negative, although it is, indeed, an all-important agent in bringing about the marvellous chemical changes of which so many substances are capable.

The physical properties of æther, however, are by no means simply negative, and although they have already been partially discussed in previous cases, yet there are still one or two points in this connection which ought to be briefly reviewed.

The effect produced by heat, in expanding almost all substances, leads one to ask whether or not heat causes expansion of æther itself. Heat, as affecting æther, consists in vibrations, and there seems no reason to suppose that the particles of æther are in any way separated from each other by such vibration. If there were a finer or rarer medium intervening between the particles of æther, and this rarer medium were set vibrating to and fro, expansion would then, no doubt result in precisely the same way that expansion of non-æthereal matter occurs.

If there is no medium intervening between the particles of æther, then it is improbable that expansion of æther is produced by heat. If we could enclose æther in æther-tight receptacles it would be easy, no doubt, to test this point; but at present there is no means known by which æther can be imprisoned as air, hydrogen, or any other gas can be confined. It is not likely, however, that æther is much expanded by heat, if at all, since, if it were so, much more pronounced electric effects would be produced by high degrees of heat. The phenomena of thermo-electricity, indeed, seem capable of fairly adequate explanation without assuming any expansion of æther by heat, and on various grounds, some of which have been already hinted at, it seems, on the whole, probable that there is no rarer medium pervading the æther; and, if not, it is difficult to see how expansion of æther can take place. Although it may never be practicable to bottle up æther in receptacles impervious to æther; a procedure from which, if successful, one would anticipate most marvellous results, yet it may be practicable to devise experiments which may, more or less indirectly, supply evidence as to whether or not æther expands by heat. Up to the present, however, the question has not been made the subject of any crucial investigations, and it can only be said that it is possible, nay probable, that æther is quite unaltered in volume by raising its temperature. All ordinary gases are capable of being liquefied and ultimately solidified, by cold or pressure, or by both combined; and as we assume that æther is, in its general characteristics, a gas, it becomes a highly interesting question whether it is likely to be capable of ultimate liquefaction or solidification. From what has been said above as to the probable nature of liquidity and solidity one cannot regard any such change of condition in the æther as at all likely in the existing universe. In reference to the influence of cold in this direction, we have already expressed the belief that the absolute zero of temperature signifies the total absence of motion in the æther. We can, therefore, only expect that, with the universe constituted as it now is, there may be approaches nearer, and indefinitely nearer, to the absolute zero of temperature, but that it will never be actually attained by any means whatever. If it were attained, æther, we may reasonably suppose, would be just what æther now is, but motionless, instead of being, as at present, in ceaseless movement. What would the effect of enormous pressure be on æther if its nature is such as we attribute to it?

Enormous pressure might displace æther from between non-æthereal particles indefinitely, up to the point where æther would be absolutely excluded, as it is, we may believe from the interior of a chemical atom; but æther cannot itself be compressed by pressure, because, in the case of pure æther, there is probably nothing between the particles of æther to be pressed out. The particles are already in complete contact, and to compress it further would perhaps be to destroy matter, and this cannot be accepted as a tenable hypothesis in the face of universal experience.

If we were able to imprison æther in an æther-tight receptacle and there to subject it to pressure, it would be possible to test experimentally the effects of pressure on æther; but under existing circumstances the result of high pressure is merely to force æther out from among the non-æthereal matter, and to compress the latter into the space previously occupied by æther. It follows from much that has been said, however, that æther exists under different degrees of pressure, and that it tends to move from regions of higher pressure to regions of lower pressure. These differences of pressure arise mainly from the varying amount of resistance met with by the æther in its movements or tendency to movement. It might be more accurate to speak of it as differences of momentum rather than as differences of pressure. The æther which intervenes between two combined atoms is prevented altogether from moving so long as the combination continues, except as part and parcel of the molecule. In the minute interstices of solids the æther moves with greater or less freedom, according to the conditions. When a molecule is broken up, the motion, which was set at rest when the atoms combined, is reproduced in equal amount. In the main the physical properties of the æther are simply, therefore, those of a gas of extreme tenuity, but it seems probable that there is the important difference that, whereas other gases have their interstices filled with the æthereal gas, there is no such gaseous fluid permeating the æther. There are, at all events, differences between the physical properties of æther, and those of non-æthereal gases, which seem very difficult of rational explanation on any other supposition than that which is supplied by the present theory.

All the characteristics which must be attributed to æther, if its existence is admitted, appear to follow naturally from the theory herein propounded. The extreme tenuity of æther follows from the evident ease with which it penetrates openings of ultra-microscopic minuteness. Its extreme mobility is a necessary consequence of its minute structure combined with the absence of any intervening particles, whereby the pressure, without a mass of æther, may differ from its internal pressure, and so cause adherence of the particles and hindrance of the free motion of the æthereal particles one on another. The absence of colour in æther, in bulk, follows from the accepted theories of colour as due to vibrations of definite wave-lengths, with special characteristics arising from hindrance to the propagation of its vibrations with equal freedom in all directions. The extraordinary elasticity of æther, which is proved by the marvellous rapidity with which it transmits vibrations, follows directly from the absolute uniformity of its structure and the complete contact of its particles one with another, giving a result almost identical with that which would be given in the case of a substance composed of an uninterrupted mass of uniform matter which is practically incompressible. What has been said above, as to the nature of liquidity and solidity, indicates that æther must be neither a liquid nor a solid, and the points of distinction between it and ordinary gases are accounted for.

We shall not here enter upon the question of the part played by æther in connection with the phenomena vaguely classified as those of life. When once we get into regions, where the knowledge of the wisest of us is at fault, everybody has such positive convictions, that he judges any new theory simply by noting whether or not it agrees, or can be twisted into agreeing, with his established beliefs. When we have ascertained what part æther plays in the better understood processes of Nature, it will be time enough to enter upon an examination of the more abstruse processes.

Some readers may perhaps be disappointed to find that a theory, professing to give a quite new interpretation to such things as gravity, chemical affinity, &c., does not involve any revolution in our various sciences; but the true philospher will recognise that facts are unaltered by being looked at in a truer perspective, and a great recommendation of the present theory will be, to him, the fact that it harmonises so entirely with the careful results of scientific experiments undertaken without any reference to this theory. To say that the far-reaching theory, which has been propounded here, has been proved at all completely in these few pages, would be to make a claim preposterous on the face of it. The work necessary to prove such a theory is more than can well be done by the combined efforts of many men abler than the writer, and it may, perhaps, be even beyond the powers of any number of able men at the present time. Yet it may be that the putting forward of this theory, glimpses of which have evidently been in the minds of many, may hasten the full investigations, of the nature and place of æther, which have been needlessly delayed by the fear of acquiring the reputation of unscientific day-dreaming. Nothing is more needed for the forwarding of science than a strong reasonable faith, which argues from things seen to things unseen. The eyes may for ever wander unintelligently over the surface of nature, unless we form some idea of what may be looked for, and then, guided by that idea, search keenly and closely to verify or disprove our intelligent preconceptions. It may be that many of the arguments set forth in these pages will fail to withstand criticism. Yet, even so, it is possible that they may indirectly lead to a true recognition of important facts which have long lain unnoticed within our reach.

Men moved with the rapid movements of the earth long before they became aware of it. They breathed the air for long centuries in utter ignorance of its nature. They are only now beginning to suspect the existence of æther, which causes the earth to move, and which is even more essential to life than the very air that we breathe.

THE END.

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July, 1906.

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By W. R. Cooper, M.A. Fully Illustrated. Price 10s. 6d. nett.

Author's Preface—Extract.—Primary Batteries form a subject from which much has been hoped, and but little realised. But even so, it cannot be said that the advance has been small; and consequently no apology is offered for the present volume, in which the somewhat scattered literature of the subject has been brought together. Recent years have seen important additions to the theory of the voltaic cell, and therefore a considerable number of pages have been devoted to this part of the subject, although it is impossible to do more than give a superficial sketch of the theory in a volume like the present. With regard to the practical part of the subject, this volume is not intended to be encyclopædic in character; the object has been rather to describe those batteries which are in general use, or of particular theoretical interest. As far as possible, the Author has drawn on his personal experience, in giving practical results, which, it is hoped, will add to the usefulness of the book. Owing to the importance of the subject, Standard Cells have been dealt with at some length. Those cells, however, which are no longer in general use are not described; but recent work is summarised in some detail so as to give a fair idea of our knowledge up to the present time. It has also been thought well to devote a chapter to Carbon-Consuming Cells. Very little has been written upon this subject, but it is of great interest, and possibly of great importance in the future.

Cooper—*See* "THE ELECTRICIAN" PRIMERS, page 11.

Ewing—MAGNETIC INDUCTION IN IRON AND OTHER METALS.

By Prof. J. A. Ewing, M.A., B.Sc., F.R.S., Professor of Mechanism and Applied Mechanics in the University of Cambridge. 382 pages, 173 Illustrations. Price 10s. 6d. nett. Third Edition, Second Issue.

Synopsis of Contents.—After an introductory chapter, which attempts to explain the fundamental ideas and the terminology, an account is given of the methods which are usually employed to measure the magnetic quality of metals. Examples are then quoted, showing the results of such measurements for various specimens of iron, steel, nickel and cobalt. A chapter on Magnetic Hysteresis follows, and then the distinctive features of induction by very weak and by very strong magnetic forces are separately described, with further description of experimental methods, and with additional numerical results. The influence of Temperature and the influence of Stress are next discussed. The conception of the Magnetic Circuit is then explained, and some account is given of experiments which are best elucidated by making use of this essentially modern method of treatment.

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Extract from Preface to Vol. I.—This work is something approaching a connected treatise on electrical theory, though without the strict formality usually associated with a treatise. The following are some of the leading points in this volume. The first chapter is introductory. The second consists of an outline scheme of the fundamentals of electromagnetic theory from the Faraday-Maxwell point of view, with some small modifications and extensions upon Maxwell's equations. The third chapter is devoted to vector algebra and analysis, in the form used by me in former papers. The fourth chapter is devoted to the theory of plane electromagnetic waves, and, being mainly descriptive, may perhaps be read with profit by many who are unable to tackle the mathematical theory comprehensively. I have included in the present volume the application of the theory (in duplex form) to straight wires, and also an account of the effects of self-induction and leakage, which are of some significance in present practice as well as in possible future developments.

Extract from Preface to Vol. II.—From one point of view this volume consists essentially of a detailed development of the mathematical theory of the propagation of plane electromagnetic waves in conducting dielectrics, according to Maxwell's theory, somewhat extended. From another point of view, it is the development of the theory of the propagation of waves along wires. But on account of the important applications, ranging from Atlantic telegraphy, through ordinary telegraphy and telephony, to Hertzian waves along wires, the Author has usually preferred to express results in terms of the concrete voltage and current, rather than the specific electric and magnetic forces belonging to a single tube of flux of energy. . . . The theory of the latest kind of so-called wireless telegraphy (Lodge, Marconi, &c.) has been somewhat anticipated, since the waves sent up the vertical wire are hemispherical, with their equatorial bases on the ground or sea, which they run along in expanding. (*See* § 60, Vol. I.; *also* § 393 in this volume.) The author's old predictions relating to skin conduction, and to the possibilities of long-distance telephony have been abundantly verified in advancing practice; and his old predictions relating to the behaviour of approximately distortionless circuits have also received fair support in the quantitative observation of Hertzian waves along wires.

Vol. III. in preparation, ready in 1906.

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In addition to the tables, instructions and other detailed information as to cables, ducts, junction boxes, &c., contained in the section on Underground Mains, it has been deemed advisable to add a chapter briefly describing the various systems employed for public distributing networks. In this, essential practical information is alone given; two and three-phase systems are dealt with, as well as continuous current and single phase, and the method of calculating the size of the conductors and the fall of pressure from the number of lamps or horse-power of motors is made clear without the elaboration of clock-face diagrams or algebraical exercises.

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