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CHAPTER I.

MOLECULAR MORPHOLOGY.

Could we but see clearly in the mind's eye the actual forms and structures of the various atoms and molecules of which crystals, plants, animals, and their organs consist, how precious the knowledge!

We frequently hear of a chess player who, though he has lost his eyesight, yet sees in his mind's eye all the pieces and the course of play so clearly, that he often wins and thoroughly enjoys the game. And so in like manner, if we but knew the normal structure and action of our organism as well as the chess player knows his game, and saw as clearly in the mind's eye that disturbance or departure from the normal structure and action which was causing us an ailment, might we not fairly hope to win the battle with that ailment, nay, even to enjoy our engagement with it while we were restoring our health!

In the advancement of the economic arts also, and the increase of the enjoyments of life, how rapid our progress if in chemical processes we actually saw what we were doing, and were no longer obliged to grope in the dark—making all kinds of experiments; no longer obliged to guess merely what is going on within—from changes of colour, or of state, or of weight; which is all that can be done at present. Nay, though we were in perfect health, and perfectly content with the amenities of life which have fallen to our lot already, what more delightful than "to see" (as Faust proposes) "all the springs and seeds of production, and drive no longer a paltry traffic in words."

That such knowledge is most desirable will not be denied. But it will be said that it is impossible to be attained. In reference to this judgment, however, let us call to mind the remark of Bacon, when discoursing upon the possible reach of discovery. They are ill discoverers, says he, who, when as yet nothing but sea appears, conclude that there is no land beyond. The truth is, that the very constitution of intelligence itself is a standing protest against such a despairing conclusion; for it is impossible to think of any particle of matter, or of anything whatever that occupies a position in space, without being obliged, even in thinking on it, to assign to it some form or other. We may indeed call it a physical point merely. But if by physical point we mean anything different from mathematical point, we can only mean a small sphere or some other definite form. Some morphological conception is inevitable, when finite existence in space is conceived.

If, then, we are to continue to think in a simple and natural way in the region of physics and chemistry at all, let us not attempt to evade this spontaneous and unavoidable judgment which affirms "form" to be a necessary attribute of every object that is at once real and occupies space to a finite extent, however finite that extent, however minute that object. Nay, as to the SPHERE let us honour the conclusion of the spontaneous intellect in favour of this form as the last word of morphology, as that form which it is most rational to assign to every fully individualised object, provided there be nothing either within or without that object to prevent its assumption of the spherical.

In a word, and to be frank, what we are now bent on showing is, that it is not only possible to discover the forms of the atoms and molecules of bodies, but that these forms,—if the atoms and molecules which possess them are capable of a fully individualised or separate existence,—are either precisely spherical or the next thing to it, that is, spheroïds either oblate or prolate.

But it may be said that there is nothing new in this, that it has been often thought, often said already, as by R. Hooke, for instance, long ago, and more lately by Dr Wollaston, who has maintained it, even to the extent of showing that on this hypothesis all the forms of crystals may be explained. Now all that is true. But there is a peculiarity in the view advanced in these pages, which, so far as I know, has not been anticipated, and which, therefore, leaves our molecular morphology without any historical authority to stand upon, and so to struggle into favour on its own merits; and it is this—Atoms and molecules we hold to be spherical or spheroidal only overhead, that is, when viewed in reference to their ætherial atmospheres or dynamospheres.

In each atom and molecule, according to our view, there is a nucleus consisting of a certain number of elemental forces, material elements, or units of atomic weight; and that nucleus in different atoms and molecules possesses very different forms and structures, from the spherical on the one hand, down to the tetrahedral on the other.

An all-embracing diagram, therefore, showing the limits between which the forms of all perfected molecules should be contained, would consist of a spherical superficies with a tetrahedral centre. Or, as we might say, it would have the regular polyhedron with a maximum number of sides for its periphery, and the regular polyhedron with a minimum number of sides for its nucleus.

Moreover, we maintain that the course of nature, in so far as molecular *synthesis* is concerned, is a progress from the tetrahedral towards the spherical.

We maintain also that the course of molecular *analysis*, ever taking place in like manner, according to the same law (that is, a homage to the spherical), during the dissociation, partitionment, or dedoublement of molecules, ever tends to provide that the parts or products of analysis shall be more spherical than the antecedent whole.

Such is our doctrine of the chemical elements as well as others; that is, those molecules which possess such stability that they are not broken up by such analytical agencies as the chemist can bring to bear upon them. Hence these elemental molecules may be conveniently named "atoms," as they usually are. Not that they are undecomposable either in themselves or in the secular course of nature; but they are so stable that all the vessels and reagents of the chemist go to pieces or suffer decomposition before they do, and thus they prove to be undecomposable to the chemist, and are "chemical atoms." They are at present about seventy in number, the heaviest (bismuth) being about 210 times the weight of the lightest (hydrogen).

I have succeeded in satisfying myself as to the structure of the nucleus in all those whose names are here given, in which there will be found almost all those which are of much interest in the economy of nature.

NON-METALLIC, .	Oxygen, Fluorine.
METALLOIDAL, .	Boron, Carbon, Silicon, Nitrogen. Chlorine, Bromine, Iodine. Phosphorus, Arsenic, Antimony, Bismuth. Sulphur, Selenium, Tellurium.
METALLIC, . .	Molybdenum, Tungsten. Manganese, Uranium? Platinum? Osmium? Iron, Nickel, Cobalt, Copper. Tin? Silver, Gold, Mercury. Zinc, Indium, Cadmium, Lead, Thallium. Lithium, Sodium, Potassium Rubidium, Cæsium. Magnesium, Calcium, Strontium, Baryum. Beryllium, Aluminum. Hydrogen.

CHAPTER II.

THE RELATIONS BETWEEN THE MATERIAL ELEMENT AND THE ÆTHERIAL.

It will be held to be against our molecular philosophy that we begin with a hypothesis which does not admit either of an experimental or an observational verification, namely, the genesis of the material element out of the ætherial. But though this relationship be denied or ignored by the student of this work, nothing of what follows is compromised or falls to the ground. This view is stated here merely for the sake of that gratification which one always experiences when, in any exposition which he undertakes, he begins at the beginning. If the reader prefer it, he may pass over this very short chapter and begin with the next, where the material element is the only postulate without any hypothesis as to its origin.

This postulate is always granted. Matter consisting of very small particles is always admitted by the physicist. But let us here remark, that if the reader who intends to give his mind for a time to the following pages proposes to do so now, and to pass over our views as to the relations between the ætherial and the material, he must consent to bring along with him some more considerate conception as to the nature of the material element than that which is popular at present. He must consent to think of the material element as something else than a very small shot or millet seed, with attractions and repulsions on the outside, obeying unknown laws and modes of action, in a region which is otherwise mere vacuum or nothingness, or else a mere interpenetrating medium of unconnected æther. This, or something like it, appears to be the common hypothesis. But when Thought, which is sufficiently severe and accurate for scientific purposes, is applied to such a notion, it falls to pieces. And for steady scientific progress and rational satisfaction in scientific pursuits, it is felt that quite another conception as to the nature of the material element is required. The following, which postulates only the pre-existence of the universal æther, is now proposed.

Let us suppose that the æther consists of equal and similar elemental forces, or centres of elemental force, or minims of reality, and that a law determining their aggregation is imposed upon them, so that in certain regions of the celestial spaces they aggregate into nebulous specks. And, further, let us suppose that in the centre of each of these specks, when that speck has attained a certain bigness, in virtue of the centripetal pressure, a nucleus is generated which, consisting in all, as it must do, of the same number of ætherial elements now confluent into one, namely, into a new centre of force, or centralised force, possesses new powers answerable to the greater quantity of substance or reality of which it consists, and we obtain a conception of that of which we are now in want. For an exposition of the argument in favour of this synthesis, with a certain degree of detail, I must refer the reader to the earlier parts of "A Sketch of a Philosophy," as also for the origin and the action of the law of Assimilation, the cosmical law which implies the law of aggregation here presumed, and on the strength of which alone we explain everything.

Suffice it to say here, that this nucleus with its atmosphere or dynamosphere of generating and attached æther, we regard as the material element or unit of atomic weight.

By assuming such units, every way similar to each other, we maintain that so many of the phenomena of the material world may be explained even now, that it is legitimate to infer that in the due course of discovery they will all be explained hereafter.

For the development of our views as to the relation of the material world to the spirit-world, I must refer to the work that has just been named, Part I. It is there maintained, *first*, that the place of the material world in the universe is that of an exquisitely beautiful precipitate or varied cloud-work in the universal æther, determined (while yet the individuals which compose its elements are so attenuated as to be devoid of all feeling) by a geometrical necessity, that is, by the operation of perfect intelligence when applied to finite elements of reality occupying finite portions of space; and *secondly*, that though at first sight material nature thus looks like a barrier preventing the return of being (when yet in the most attenuated and apathetic state) to that state in which the individual shall have recovered sensibility, and be capable of enjoyment, yet it is not really so, inasmuch as material nature tends to culminate in organisms whose special function is to be the mother and nurse of spirits, and thus to complete the cycle of being, carrying up creation again to the spirit-world and towards the fountainhead.

CHAPTER III.

MOLECULES.

Our Primal Elements.—Our least molecule is that which has been already indicated, namely, an ætherial sphere with a group of four material elements constituting an elementary tetrahedron as its nucleus (see Plate I. fig. I. Δ). Viewed in reference to any particular region in space, as, for instance, the ground beneath our feet, or the bottom of the plate on which the diagram is the first figure, it is a trigonal pyramid. And in this point of view it is represented in the diagram. As to the lines joining the centres of the four constituent forces in that diagram, they may be regarded as the last resultants of the attractive and repulsive agencies of these forces, as they are constituted in the dynamisphere or ætherial atmosphere of the tetradic combination.

And now, let me lose no time in adding that, happily for our progress and for the simplicity of the science of molecular morphology, in so far as our planet at least is concerned, all molecules are constructed by the *synthesis* of elements of this kind, either single or coupled base to base (see Plate I. fig. II. ℌ). No others are found or required.

These, our primal architectonic elements, then, let us shortly name the Tetrad, and the Bitetrad or Hylagen.

Our Ultimate Elements.—Similarly our molecular *analysis* gives as its least separable particles not a group of four indeed, but yet of no more than five units, or else five tetrads united by an edge in each as the common axis of all (see Plate I. figs. III. H, and IV. B). For five units and five tetrads so united (the last, however, having ultimately only five instead of five couples of units in its equator) are the smallest numbers after the bitetrad itself, which possess the skeleton of the sphere, that is, an axis with two poles which are similar to each other, and an equator evenly placed between the poles.

Light, Common, Baric, and Barytic Elements.—In all the elemental molecules just referred to, the units constituting them exist separate, invested within the molecular structure as well as outside of it by their proper æther. It is conceivable, however, that under intense pressure, or other unifying action, the four units in the primal tetrad may be brought and may continue to exist close together, all the æther having been extruded from between them. Now, when this has occurred, this condensed tetrad may become a genetic unity in the construction of molecules, like the single material element itself. Thus we shall have isomorphous elements (chemical atoms) of two classes, the atomic weights of the atoms in one class being four times that of the other, while at the same time their atomicities and general modes of functioning may be expected to be highly analogous.

As the lighter sort of molecules is by far the most abundant in this planet in the present epoch of nature, we may call it the common sort, while we may call the other the baric sort. Moreover, since H and ♅ are already isomorphous, it will save words if we call the heavy sort of H (say **H**) Baric, and the heavy sort of ♅, which must be still heavier (say **♅**), Barytic—a word which looks like a superlative, and suggests a substance (barytes) which belongs to this order.

As illustrations of these different orders of elements, it may be mentioned that selenium is baric, and tellurium is barytic sulphur; that antimony is baric, and bismuth is barytic phosphorus, while arsenic is a hybrid between light and baric; that bromine is baric, and iodine is barytic chlorine; that rubidium is baric, and cæsium is baryticpota s-sium, &c.

Such, then, are all the elemental forms and structures and orders of elements which the student of molecular morphology has to keep in his mind's eye, as the beginnings and endings, and the continually recurring forms in the science.

Molecules.—But we cannot remark too soon, that from the fundamental operation of our cosmical law as the law of the spherical, these elemental forms, and indeed molecular forms generally, are to be expected in nature and the laboratory, not single and free one by one, but aggregated and clustering together into groups or molecules. Scarcely any elemental structure taken by itself is spherical. Most elemental molecules are, therefore, under the law of sphericity still active, and more or less active according as their forms are more or less defective in the spherical. And the mode of their activity is to improve their sphericity. Now this they can only do by coming together into groups or molecules, which shall be more nearly spherical than the single elements when existing each by itself. Thus atoms of H and ♅ will tend to aggregate into a molecule such as H_{20}, and atoms of B will tend to aggregate into a molecule such as B_{12} (see Plate I. figs. v. and vi). Thus are our principles of molecular synthesis as definite as those by which we obtain the single elements. And here we have to note three kinds of molecules—1*st*, Isometrical molecules; 2*d*, Differentiated molecules; and 3*d*, Isometrical molecules composed of those which have been differentiated, and therefore themselves composite isometrical molecules.

Isometrical Molecules.—As to these we may remark, what will be seen immediately on inspection, that one of our forms (see fig. B) is a *pentagonal* bi-pyramid; while the others (see figs. H and ♅) are *trigonal* bi-pyramids; the equator in B being a pentagon, and in H and ♅ a trigon or triangle. Now, it so happens that if we include in the trigonal order the hexagonal, to which the trigonal gives rise in a few cases (see Pl. I. fig. XI. aq), all molecules whatever, as they successively come forth, show themselves to belong either to the pentagonal or to the trigonal order. And as soon as an element is met with, it is of the first importance to mark which of these orders it belongs to. For under the law of unification most chemical atoms tend, as has been stated, to betake themselves into the molecular state. Moreover, the resulting molecule ever tends, under the law of sphericity, to be as spherical as possible. And therefore all the separate atoms of which it consists tend to point their axis to a common centre. Now, when pentagons or pentagonal forms do this, geometry shows that 12 must concur in order to complete the system, thus developing the regular *dodecahedron* of geometry (see fig. VIII.), the *dodecatom* of molecular science (see fig. VI.). When, on the other hand, trigonal forms concur, then the same geometry shows that 20 are required to complete the isometrical structure when most nearly representing the spherical in form, and there results the *icosahedron* (fig. VII.) and the *icosatom* (fig. V.). Thus our element B in the molecular state gives B_{12} (see the figure). Our element H or ♅ gives H_{20} or $♅_{20}$ (see the figure), and of these the skeletons or lines of union give the dodecahedron and icosahedron respectively (figs VII. and VIII.)

Differentiated Molecules.—An isometrical molecule having been constructed into an unity, nay, any molecule while being constructed, is, of course, when considered as an unity, "dissimilar" to the single elements or members of which it is being constructed or is constructed. The synthesis, therefore, under the general law of chemical affinity (that is, the tendency of dissimilars to unite with one another), tends to go on after an isometrical molecule has been constructed; and thus there result differentiated molecules of many kinds.

Of these one of the most interesting is that in which the *structure* is differentiated while the *form* continues to be isometrical. Thus, with regard to the two regular polyhedrons towards one or other of which almost all molecules, according to our views, tend to conform, namely, the dodecahedron and the icosahedron, geometers show that their salient parts are so related to each other that each tends both to circumscribe and to inscribe the other symmetrically. Suppose, then, that a dodecatom has been constructed, it may be differentiated symmetrically by the apposition of 20 elements of the same kind in its surface, so that it becomes double-walled—the inner wall consisting of 12, the outer wall of 20 similar elements. And the same will tend to be the case should the inner wall be an icosatom; in that case the coating will be a dodecatom. In both, the number of elements in the molecule will be $12 + 20 = 32$, and the molecule is differentiated while yet it continues isometrical. Hence a fine stable molecule—

$$X^{12+20} = \overset{32}{X}.$$

But another case is no less frequent. Thus, an isometrical molecule, such as X^{12}, having been constructed, a single element is added, giving

$$X\overset{12}{X} = \overset{13}{X}.$$

But this combination, like the tetrad itself, is heteropolar, dissymmetrical, pyramidal. It therefore cannot exist separate, but must move about till it rests on something else. Now, the simplest case of rest will be when one such simply differentiated molecule applies itself to another of the same kind, and they continue united, as it were, base to base. We thus obtain

$$X\overset{12}{X}\overset{12}{X}X = \overset{26}{X}.$$

And such is our first formally differentiated molecule. We shall find that they are many both in the crust of the earth and in the laboratory of the chemist. But when single elements or single atoms of X are supplied in good number compared with molecules of the same, such as X^{12}, another result is to be expected. In this case, very soon after an atom of X has attached itself to one point of X^{12}, another atom of X will attach itself, through the operation of the law of symmetry, on another point of X^{12} directly opposite to the first. And thus there will result

$$X\overset{12}{X}X = X^{1+12+1} \text{ or } \overset{14}{X}.$$

Now, in either of these cases the molecules thus differentiated are no longer free to act in the line of any one of their six axes. They are determined by their now prolate forms, both as to their own modes of action, and as to their position in relation to those adjacent to them. Moreover, their activity is increased; because this development of eminent poles is a departure from the spherical. So also is their cohesion or stability increased for the same reason; for they are differentiated, or made to consist of dissimilar parts to a greater extent than before. We are therefore to expect that most molecules, as they are met with in nature, most of which have undergone the ordeal of planetary development, will be differentiated, that instead of $(X)^{12}$ for instance, we shall usually meet with $X\overset{12}{X}\overset{12}{X}X$ or $X(\overset{12}{X})X$ or $Y(\overset{12}{X})Y$, or $Y\overset{10}{X}Y$ or the like.

Composite Molecules.—But isometrical molecules, when thus differentiated, have departed from the spherical form, which they possessed before. They have become axial or prolate. They must therefore, as has been just stated, have acquired activity under the law of the spherical. And it is easy to see that they will tend to aggregate again into larger molecules; for in these larger molecules they may hold the position of radii, and thus the whole structure be spherical, notwithstanding the axial or prolate form of each of its constituents. Thus, beyond differentiated dodecatoms and composed of them, we are to expect composite dodecatoms consisting of twelve of the former disposed around the common centre. And beyond differentiated icosatoms when they have trigonal poles, we are to expect isometrical composite icosatoms. But confining our attention here to the differentiated dodecatom, after $X\overset{12}{X}X$, we shall have the large but isometrical molecule

$$(X\overset{12}{X}X)^{12} = 168\,X\,.$$

And such, we shall find, are the molecules which are most generally met with in the crystals of the mineral kingdom, the volume of each occupying 8 or 16 aqueous molecules, or rather a half or one ice volume. But these facts will appear most plainly as examples occur. Let us, therefore, rapidly pass on that we may meet with examples as soon as possible.

Atomic Weights.—Since hydrogen holds such an eminent place in the chemistry of the day that it is taken as the unity of atomic weight, and since, therefore, atomic weights cannot be deduced and compared with the tables in chemical works unless we know the true atomic weight of hydrogen, we may mention here that our H (see fig. III.) is the hydrogen of our system. Nor is it drawing very largely upon the credulity of the reader to ask him to believe this in the meantime if he is afterwards to believe any part of our molecular morphology at all. For the hydrogen of the laboratory is at once the lightest and the most elastic or mechanically perfect of all known elements. And so is our H the lightest molecule which, according to the principles of our system, can be separable from others and insulable by itself; for since each of its poles is a single unit only, and its equator consists of three units only (which is the smallest number of points that can determine a plane), H is the simplest molecule that can possibly have two poles which are similar to each other, and an equator lying evenly between them. For the same reason, also, its mechanical perfection, and, consequently, its resilience under strain, and therefore its elasticity in general, must be most perfect as will soon appear.

As to the tetrad (see fig. I.), it is only a hemiform or pyramid, not with two similar poles opposite to each other, but with a base opposite to each pole, and therefore, as we shall see, formed for resting on and adhering to something else, not for rising into the æriform state by itself. The atomic weight of our hydrogen, then, is $1 + 3 + 1 = 5$. And this, according to our system, is not a conventional number. It is an absolute atomic weight. And that the atomic weight of our hydrogen should be 5, while the conventional atomic weight of this element (which is the usual basis of the tables of atomic weight in the authorised systems of chemistry) should be unity, is a very happy coincidence; for $2 \times 5 = 10$ and $\frac{10}{2 \times 5} = 1{\cdot}0$. In order, therefore, to convert the tables of atomic weights in chemical works, their numbers being taken at the lowest, into the absolute scale of this work, the decimal point requires only to be removed one cypher to the right and these numbers halved. Thus magnesium, whose lightest atomic weight on the conventional scale is 12·0, becomes on the absolute scale $\frac{120}{2} = 60$. Silicium from 14·0 becomes $\frac{140}{2} = 70$. Calcium, from 20·0 becomes $\frac{200}{2} = 100$, and so on.

These things premised, let us no longer delay to enter upon the elemental synthesis of the molecules of bodies, and that not when viewed in their purely morphological relations, but in their genetic relations, that is, in the order of their natural development and association. They have been presented to the student in their morphological relations in our "Sketch of a Philosophy" Part II.; and there also, and in Part I., the law of Assimilation (whose origin we have traced to the relationship between Creator and creation), and whose operation alone we invoke to explain all the phenomena of Nature, has been so fully illustrated that we need not recur to an explanation of it here, but may proceed at once to apply it.

But here a difficulty presents itself as to a commencement of our proposed synthesis of molecules. There are two formative principles in the cosmos equally aboriginal, and which appear to be everywhere coordinate, namely, analysis and synthesis (see A Sketch, &c., Part I. chap. vi.) But they are the opposites of each other, and suggest states of things at the beginning which are the opposite of each other. They suggest, as the product of a complete antecedent synthesis, matter in the densest and most massive state—a state in which single material elements are packed as closely together as possible. They suggest, also, as the educt of a complete antecedent analysis, matter in the rarest and most diffused state possible—a state in which each material element has secured its own individuality, and its legitimate volume or proper sphere in space in which it may exist. Now, since both the operations which work towards these states are simultaneous in Nature, and the actual web of Nature is the weaving of both, it follows that in order to reach and to represent Nature truly, it would be necessary to begin with both simultaneously. But this is impossible; we must, therefore, make an election between the two. Now, as that which is most in accordance with chemical habits of thought, and which holds out a greater likelihood of verification, instead of soaring for a long time in the sky and dealing with matter in the rarest and most fully analysed state, becoming concrete only in meteoric matter, it would be desirable rather to descend into the Plutonic abyss, where we might assume it to exist in the most condensed state.

But as an important point in the verification of the views here advanced consists in the power with which our theory invests us, of deducing, independently of the use of the balance, the specific gravities of liquids and solids, as well as æriforms, and as this deduction requires the knowledge of the atomic weight of an unit volume of water, and if possible of ice also, it will be well, first of all, to determine these points if we can. And for this let us make an ascent for a short time into the azure, or rather, indeed, into the celestial spaces.

Let not the reader recoil if from this hint he infer that as we have presented to him the first elements of material nature disseminated in the æther, so are we now to introduce him to aqueous matter in the same region as the finest and most abundant product of primal synthetic action there. No doubt, if he be wedded to the existing philosophy of the chemistry of the day, he will say that such an idea is absurd. But science and philosophy down to the age of Newton, and Newton himself, did not say so. And we may say safely, that however deeply disparaging to the interpretations of Nature by modern chemists our molecular philosophy may be, and however unmeasured the disparagements which they may throw upon it, yet, looking to the whole history of philosophy, it is not our view, it is their interpretations, that are exceptional. It is the conception of some 70 different kinds of matter essentially distinct from each other, and neither in any time nor in all eternity transformable into each other, that is the novelty in the history of philosophy. And yet on such a conception the whole of modern mineral geology is built!

CHAPTER IV.

THE NORMAL SYNTHESIS OF MATTER IN THE CELESTIAL SPACES AND ITS FIRST AQUEOUS PRODUCTS.

The Tetrad (see Plate I. fig. I.)—Let us suppose that in the celestial space which we now contemplate, the æther is sown with matter existing in the state of single material elements, or, as we may say, the common vapour of bodies. Then, under the law of Assimilation (as to the space they occupy) mutual attraction will ensue; the material units will come together. Moreover, when their primal diffusion is most perfect, and their commencement of synthesis most simple, they will, of course, first come together in couples. Thus as we assume that the individuality of the material elements is such as to prevent them, when they are as near to each other as they may be, from fusing together and becoming confluent into one, we obtain, as the first product of synthesis in the celestial space, a couple of material elements, unified, indeed, in their ætherial atmospheres, but as to their centres distinct—these centres thus marking the two foci of an ellipsoid which is constituted by their united ætherial atmospheres, and therefore by the couple as a whole.

But the form of this couple, this ellipsoid, is inevitably prolate, while molecular synthesis ever aims at the spherical. What, then, will the next step in the synthesis be? Plainly, it will be the union of two such couples symmetrically or crosswise; for when they are so united, then, by the unification of their ætherial atmospheres as before, an isometrical or spherical surface is obtained; while, as to its nucleus, as defined by the position of the four centres of its constituent units, it must be a tetrahedron, also an isometrical form. And thus, as the product of the first fit of synthetic action, in the circumstances which we have conceived, we obtain what we have shortly named the Tetrad, its absolute atomic weight = 4.

But this tetrad exists in a region where there are also single units of matter, and other tetrads. With either one or other of these, therefore, according as it first meets the one or the other, this first tetrad must, when a synthetic phase of action exists in that region, unite, and, under the law of symmetry and sphericity, it must place itself in symmetrical relationship with them.

Hydrogen (see Plate I. fig. III.)—Now, with respect to the single material elements should they first come in the way of the tetrad, this symmetry is effected when a tetrad and a unit unite, so that the unit may be poised opposite the centre of one of the four facets of the tetrad, at the same distance as the unit in the tetrad on the other side.

From this union there results a bi-pyramidal nucleus (figure H). Now, this is a molecular structure of singular mechanical perfection; for while it consists of no more than five equal and similar forces held in position, and moved by equal and similar attractive and repulsive agencies, these five forces are so disposed, in the structure which they form, as to constitute no fewer than seven triangles of forces! The stability, therefore, the resistance to strain, and the resilience, more familiarly the undecomposability and elasticity of this element, must be extreme.

We shall see, as we proceed, that it represents the hydrogen of chemistry in every particular.

But is the mode of synthesis which we have now traced the only one possible in the circumstances which we have conceived? After two units have come together so as to constitute a couple, may not a single unit, it may be asked, instead of another coupled unit, as we have supposed, enter into union with the given couple, so as to give a triangle of forces instead of a tetrad as the first product of synthesis after the couple? Be it so. The issue will forthwith be the same as before. This triangle of forces, which, under the law of sphericity, is only an equator, not a complete form, will, under that law, immediately unite with two other units, one on each side of itself; in other words, it will adjust to itself another couple, so that that couple may be an axis, or at least give poles to the equatorial form, consisting of three units. But such a combination of five units is the very same as that which we obtained before, viz., H.

Thus, as the first step towards the condensation of the common vapour of matter, the formation of hydrogen presents itself to us.

Hylagen.—But there is one incident that must prevent this result, an incident which may be expected to occur very frequently, and that is when, instead of a single material element entering into union with a tetrad, so that, taken together, they shall constitute an atom of hydrogen, or, instead of tetrads arranging themselves in sets of four around one in the centre, which gives four atoms of hydrogen, two tetrads, just generated beside each other, clap together base to base. From this there must result a new kind of hydrogen, with two units instead of one in each of the three equatorial angles (see Plate I. fig. II. Ḫ).

Hydrogen transformed into Hylagen.—But such a contingency, such a result, does not disturb our synthesis. Nay, where matter in single elements, or the common vapour of matter abounds, as in the region of space which we are now contemplating, atoms of hydrogen—their atomic weight 5—must ever tend to grow into this heavier sort whose atomic weight is 2 × 4 = 8, instead of 5. Thus, the form of the atom of hydrogen, considered irrespective of the action of heat, and viewed in reference to its circumscribing ellipsoid is prolate, the axis being to the equatorial diameter nearly as 10 to 7. In order to fulfil the law of sphericity it is in want of more matter on its equatorial region. Wherever, therefore, matter in single units and sufficient repose or cold exist in the ambient, an atom of H may be expected to attract to itself three units, one or each of the three angles of its equator, thus making each angle of that equator to consist of a couple of units. Moreover, these added units, according to the existing conditions of existence, will place their axes either parallel to the equator or to the axis of the atom of hydrogen into which they have entered.

And thus hydrogen, if existing alone, in the circumstances which have been mentioned, will tend, sooner or later (or as we say "secularly"), to be transformed into bitetrads or hylagen.

The Tetratom of Hydrogen (see Plate I. fig. IX.)—There is one case, however, in which this transformation of H into H̥ will be prevented. On inspecting the atom of H it will be seen that there are on it five points, where other atoms of H or H̥ may enter into union with it. Now, where existing heat does not forbid such union, and where atoms of H abound in the nascent state, the three points on the equator of an atom of H will be immediately supplied, not by three units, so as to generate an atom of hylagen, but by three other atoms of H coming on and remaining attached by their poles; for the equatorial angles of an atom of H are constituted by four edges, while the polar angles are constituted by three only; these polar and equatorial parts are, therefore, dissimilar to each other, and, like dissimilars in general, they must tend to unite. Thus, to a central atom of H three atoms of H will tend to be added, extending their arms in the equatorial plane of the primary or central atom. We thus obtain the tetratom of hydrogen (see fig. $\overset{4}{H}$).

Its normal Genesis.—But here, let us remark, that while our theory thus provides for the genesis of tetratoms of hydrogen in detail, it also provides for their genesis all at once, and in a much more elegant way. Thus, let the entire medium in the celestial spaces which we are now considering have resolved itself into tetrads. If these are prevented from clapping together into couples, base to base, so as to generate the bitetrad (fig. H̥), or in sets of five, by an edge of each as a common axis for all, so as to generate an atom of our boron (fig. B), if they continue separate and arrange themselves under the law of symmetry in the simplest manner possible, then four will place themselves around one in the centre, so that a base of each of the four may be symmetrically poised over each of the four angles of the central tetrad. Now, when this arrangement has been established, the five tetrads thus tetradically grouped is one and the same thing as a tetratom of hydrogen! And as soon as three of the atoms of H have placed their axes in the equatorial plane of the fourth, as in our diagram of H^4, then

$$\overset{5}{\Delta} = \overset{4}{H}.$$

Thus we are led to regard hydrogen as normally given in the tetratom.

Its Importance in Nature.—And this is important to remark, because we shall find the tetratom of hydrogen to be a molecular structure of such importance that the very existence of the vegetable kingdom seems to depend upon its functioning. Thus, viewed in its ætherial atmosphere, the tetratom of hydrogen is no better (when considered in reference to the law of sphericity) than an equatorial annulus. It is intensely oblate or negative. Now, we shall find that oxygen agrees eminently with it in this respect. Hence, in virtue of the repulsion which operates between forms which are similar to each other, the tetratom of hydrogen tends to repel oxygen as much as the single atom of hydrogen tends to attract it. Accordingly, H^4 appears to have power to expel oxygen from carbonic dioxide, and to deliver its carbon in the uncombined state into the vegetable, there to constitute a tissue or tenuous structure which continues concrete, while its aeriform part (oxygen) is given off to the atmosphere. But from the consideration of such phenomena we are yet far distant.

The Triple Tetratom of Hydrogen.—Still it is good to be remarked here, at the very commencement of molecular synthesis where we now are, that the functioning of the tetratom of hydrogen must be of such a kind as has now been specified. But further, from the oblate or negative form of the single tetratom it follows, under the law of sphericity, that one tetratom will tend to place itself on each pole of a central tetratom, so as to give the Triple Tetratom

$$\overset{4}{H}\overset{4}{H}\overset{4}{H} = \overset{12}{H}.$$

And this, considered as existing in a very expanded state, and merely as the basis of arrangement of free atoms in an aeriform, is probably that in which hydrogen, when in a state of repose, usually exists.

The Hexatom of Hydrogen.—But in as much as the single atom of H is prolate, while H^4 is oblate, these two will tend to unite. An atom of H will place itself on each pole of an atom of H^4, thus generating H^6 (see Plate I. fig. x.) The mode of synthesis is the same as we have met with already when a single unit of matter placed itself on each pole of a triangle of units, so as to generate a single atom of hydrogen.

We thus obtain the hexatom of hydrogen (fig. x. H^6). Viewed in reference to the law of sphericity, its form is the same as that of the single atom; and no improvement in respect of sphericity can be made by any further addition after the same mode. Wherever synthetic action is strong, therefore, and there are no single atoms of hydrogen present, what we are to expect is that these hexatoms, as perfected structures, will unite with each other as their symmetry determines, that is, so as to give a hexatom of hexatoms, and after that a hexatom of these composite hexatoms, that is, $6 \times 6H^6 = 36H^6$, &c.

The Hexatom Transformed into fully Expanded Vapour.—Suppose now, these hexatoms to exist in a region where matter in single units also exists, what we have here specially to remark is, that in each and all the hexatoms the central atom of H is secured against the incidence of three units of matter on its three equatorial angles, these angles being engaged already by the atoms of H, which are in union with them. The central atom of H in H^6 is therefore secured against transformation into an atom of ♅. In a celestial space, then, impregnated by the presence in it of material elements, all of them existing in a separate state, or as the common vapour of matter, after the genesis of hydrogen itself, we obtain the following secular equation, in which the astronomical sign of the sun is used as the symbol of the single material element, or unit of matter—

$6 \times 6H^6$ or $6 \times 6HH^5 + (6 \times 6 \times 5 \times 3\ \odot) = 6 \times 6$H♅$^5 = 36$H♅^{5}. (See for fig. H♅^{5} fig. $HH^5 = H^6$, which is the same in form).

Now this structure, H♅^{5}, so long as it possesses the form of genesis, that is, so long as it carries an atom of ♅ on each of the five points of union of the central atom of H, for a reason which will presently appear, we may call fully expanded vapour, or superheated or wholly uncompressed steam.

Expanded Vapour Collapses into Common Vapour (see fig. XI. aq). —This hexatom of H♅^{5} is capable of assuming a variety of forms. There is one form, however, which in symmetry and sphericity far transcends all the others, and in which, therefore, all the other forms must culminate; and that is when all the six isomorphous elements of which it consists have come close together, and so as to place all their axes parallel to each other and to the geometrical axis of the combination, and all their equators in the same plane (see fig. aq). From this there results a structure which, viewed in its ætherial atmosphere, is eminently spherical and symmetrical—which, viewed in its peripheral aspect, is positive, while, viewed in its central aspect, it is negative—which is so well adapted for vibration or palpitation that it must be a perfect storehouse of heat—which is so finely differentiated by the insertion of one atom of H into the circle, or rather the regular hexagon of which the other five members are atoms of $\mathfrak{H}$, that in free space it must be very stable, while yet it is so easily transformable that it must be very tender. In short, here we have a molecular structure, which in every physical feature possesses such morphological eminence that, if our theory be truly representative of Nature, we have not only to look for, but we must find some material agent in Nature holding the place of a primæval substance, and characterised by such properties as immediately present themselves to the eye on the inspection of this our molecule of aq.

But what as to the atomic weight of this exquisite structure—which, does it not at once remind us of the form of a minim snow-flake or "ice flower?" Since it is $H\mathfrak{H}^5$, it is $5 + 5 \times 8 = 5 + 40 =$ *i.e.*, $1 + 8 = 9$, when $H = 1$. Now this, it is well known, is precisely the specific gravity of common vapour when that of hydrogen is taken as unity.

And what as to our two forms of this structure, both of them symmetrical, and therefore both capable of the fully insulated or æriform state, the one that which we have indicated under the names of fully expanded vapour or superheated steam, and the other as common vapour or steam? It is only to be expected that the former shall occupy at least double the volume of the latter. If, then, steam imprisoned in a boiler should be raised to a continually increasing temperature, what we are to expect, according to this view, is that it will begin at a certain temperature to observe a rate of expansion much greater than that proper to æriforms in general, and, in fact, as soon as it has acquired the heat requisite to maintain it in its new form, will rapidly expand into at least double its volume, thus bursting vessels which would have been strong enough to confine it in its common form. Now, does it not look as if here we have an explanation of that bursting of boilers which often occurs, which is so unlooked for, so fatal, and unaccountable on ordinary views?

Aq transformable into HO (see Pl. I. fig. XII. HO).—But what is the other easy transformation of $H\mathfrak{H}$ to which I have alluded? So long as it is let alone in free space an atom of aq ought to be, as has been stated, very stable in the hexagonal form. But suppose there come into the field in which it exists, and near enough to it, an atom of the pentagonal order of forms, such as B (see Pl. I. fig. IV. B), then, in consequence of their dissimilarity, aq and B must tend to unite, and that, in the first instance, on the same axis, as the readiest mode of union under the law of symmetry. But on the same axis they cannot unite, for aq is hexagonal on its polar regions, and B on the same regions is pentagonal.

What, then, will happen? On a minute inspection of the structure of the atom of aq, it will be seen that it can adapt itself beautifully to a pentagonal pyramidal form, such as is the polar region of the atom of B. It will be seen that the five atoms of Ḫ in $HḪ^5$, which is the primal representative of aq, can—and that by one movement—unite with each other, poles to equators, and face to face, and apply themselves to B, so that the polar regions of the latter shall be a perfect model for them in their new form, that new form symmetrical (see Pl. I. fig. XIII. O), yet such that it is wholly in want of an axis—a want which, however, the atom of H, thrown out of the circle of 6 in aq, can admirably supply. Thus aq, when it enters into union with a molecule of the pentagonal order, will be transformed into HO (see the fig.), and when coupled H◎H = H^2◎. Auct.

Oxygen (see Fig. XIII. O).—And what, let us ask, does this new element, which we have denoted by the letter O, represent? If it be to nature what it looks like, it will be what the blood disk is to the animal, what the life-buoy is to him who without it would be drowned. It is a double concave-lens-form. Both its poles are re-entrant. They are wholly in want of matter. When existing in single atoms, therefore, it will tend to unite, to squat down upon almost anything that does not repel it by being mailed in it already, for it cannot be so ill-conditioned in a morphological point of view, as when it is existing free and alone. Moreover, in every morphological feature O is obviously the very counterpart of H, and its atomic weight, which is that of $Ḫ^5$, is $5 \times 8 = 40$, that is 8 when $H = 1$.

Oxygen Gas (see fig. XIV. ◎).—But a single atom of O is very oblate, while two on the same axis give a form whose atmosphere at least may be spherical. On rising into the æriform state it may, therefore, be expected that atoms of O will couple, so that an unit volume of oxygen gas corresponding to an unit volume of H or of Aq, will have a specific gravity of 16 when $H = 1$. Let these remarks suffice, in the meantime, for showing that this new element O represents oxygen, and its coupled molecule ◎ oxygen, gas.

I will only add that HO is, like the primal tetrad, dissymmetrical and heteropolar. By itself, therefore, it is uninsulable. But a couple when united by the atoms of O, which are their bases, are (like a couple of tetrads united by their bases into a bitetrad), symmetrical, and therefore mobile, and possibly insulable. And thus our theory justifies both the old and the new view of the experimental chemist; it justifies both the formula HO and H_2O, where O in the first is 8, and in the second 16 when $H = 1$.

What a marvellous thing, then, if this molecular morphology, which it has fallen to me to propound, is no more than a mere imagination, really deserving of no better treatment at the hands of the chemists than that which it receives! Can the legitimacy, nay, the necessity, of the constructions and transformations which I have placed before the reader be denied if the first principles of our theory, nay, the law of symmetry only, be admitted? No. And if they cannot, what is to be thought of such a crowd of coincidences, presenting themselves all at once, in connection with our aq and HO, and the well-known properties of common vapour, and the oxygen and hydrogen into which our atom of aq may be resolved? Is it said that these coincidences are merely accidental? Such a peculiar atomic weight as 45 or 9 accidental! and its normal resolution into two elements, whose atomic weights are 5 and 40, or 1 and 8, also accidental! Its intensely vibratory or palpitative structure, that is, its capacity for heat compared with other elemental molecular structures, compared with O for instance, accidental! its hexagonal structure and form, so like a minim snow-flake, or the inflorescence of plants of the monocotyledonous order, in which an aqueous tissue predominates, accidental! If these, and all the other coincidences which might be pointed out, of our theoretical structure, with the properties of the aqueous element, as known in nature and the laboratory, be merely accidental, then here, assuredly, is a greater miracle than any of those of Egypt. But miracle or no miracle, it appears that the chemists of the present day don't and won't give their mind to it. But to proceed.

Why aq is so stable.—In consequence of the fact that one of the six elements constitutive of an atom of aq is an atom of H, while the other five are atoms of ♅, the structure of aq is differentiated, or consists of dissimilar parts. And, therefore, under the general law of the union and subsequent cohesion of dissimilars, these parts hold together, and the whole structure is more stable than it would have been had all the constitutive parts been identical with each other.

Why aq is a Vapour and not a Permanent Gas.—But this differentiation implies at the same time a want of symmetry in the structure of aq. In fact, having on one side an atom of H, whose atomic weight is only 5, while on the five other sides it has atoms of ♅, whose atomic weight is 8, every atom of aq has what we may call a weak side. Atoms of aq will, therefore, tend to lean against something which can supply the want of matter in the atom of H, and impart strength to it. And if nothing else be supplied on which they may lean, they will lean upon one another—the weak side in one atom upon the strong side of the adjacent atom. And thus a molecule of aqueous matter will form; and this molecule, being no longer capable of the fully individualised or æriform state, will condense. In short, aq will be a vapour and not a permanent gas—not such a gas as we may conceive H or 𝕆 to be capable of constituting—at least in the absence of overpowering pressure, or a degree of cold incompatable with the æriform state. With regard to both H and ◎, neither displays any weak side or dissymmetry which may determine towards condensation. But with aq the case is different. And the question for us now to ascertain is, on what way atoms of aq will condense, and what will be the molecular forms that will result?

Now, this we shall state in the fewest words possible, because the forms referred to are adapted to eye-sight, and ought to be represented by diagrams. And when that is not the case, no description, however detailed, proves satisfactory; while to procure the requisite diagrams, there must be a concurrence of purchasers with author, else the cost is too much.

Our New Symbols.—Meantime something may be done to assist the eye by the use of types already in the printer's hands. Thus, let us take—

⸸ or † A dagger, placed up and down on the page, instead of the letter H, for hydrogen.

∞ A figure 8, with face equally broad all over, which is the atomic weight of an atom of oxygen where H = 1, and which when placed horizontally as ∞, at the same time somewhat resembles a section in the plane of the axis of an atom of oxygen, instead of the letter O.

✳ The astronomical sign for a fixed star, for an atom of vapour, which it resembles in its hexagonal structure, instead of the two letters aq, which are very inconvenient.

The Tetratom of Vapour.—As to the molecular structures, then, which the aqueous element, or common vapour, will give during a normal or gradual process of condensation (since its structure is hexagonal and therefore trigonal also), the first group, as in the case of the material unit itself, and of hydrogen also, will be the tetratom which, when the poles of the atoms of aq are supposed to be directly under the eye, may be thus represented—

$$\begin{matrix} \ast & & \ast \\ & \ast & \\ & \ast & \end{matrix} \quad = \quad 4aq.$$

Unhappily, when this tetratom is held up so that the axis of the combination is vertically before the eye, or in the plane of the paper, it can only be represented, if it is in any measure to exhibit the symmetry, by substituting $\ast^{2}$ for $\ast\ast$. Thus—

$$\ast\ \overset{2}{\ast}\ \ast \quad = \quad 4aq,$$

the fourth aq being supposed to be behind the central atom.

The Hexatom of Vapour or Moisture.—But, like the tetratom of hydrogen, this tetratom of vapour is very oblate, very much in want of more matter on the poles. As in the case of the tetratom of H, therefore, by the incidence of an atom of vapour on each pole, we shall immediately have the hexatom. But here the dimorphism of the aqueous element may come into play. The element of moisture added on each pole may exist either as aq or as HO, for the trigonal pyramidal form of H is conformable to the hexagonal (and therefore also the trigonal) re-entrant poles of aq. Thus, in different conditions of existence, we may have—

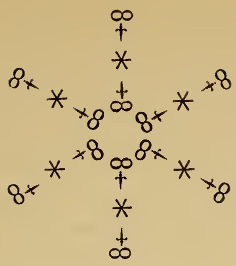
```
                          ∞
      ∗                   †
    ∗∗∗²      or        ∗∗∗²      =      6aq, or 6HO.   Auct.
      ∗                   +
                          ∞
      4                   4
   aqaqaq              OHaqHO
```

Now, of these, the latter being finely differentiated and compactly built, must be comparatively stable; and this we shall find as we proceed that it is.

The Triatom of Moisture.—In fact, when the three loosely attached atoms of aq on the equator of aq^6 are driven off by the drying of the chemist, previously to his analysis of the substance in which the moisture exists, the axial structure is so stable that it survives a considerable ordeal. In the diagram (see Pl. I. fig. xv.) the last lines of this beautiful structure are given. With our adopted symbols it may be thus represented—

```
                                  ∞
                                  †
Moisture as an alcohol,           ∗      =      3aq, or 3HO.   Auct.
                                  +
                                  ∞
                               OHAqHO
```

Dead Water.—But such a structure taken singly is highly axial or prolate in form. If, then, it cannot restore its own sphericity, each by laying hold again of 3aq for an equator, so as to become $OHaq^4HO$, they will aggregate into a group around a common centre, in which, each being a radius, its prolate character when by itself will not interfere with the sphericity of the whole. And what will the structure of that group be? To this it is to be answered, that since both the poles of OHaqHO are pentagons, the group, when completed under the law of symmetry, must consist of 12, and the oxy-hydro-aqueous molecule resulting must be a dodecatom, of which the following figurate profile may give some conception.



$$(OHaqHO)^{12} = 36aq = AQ.$$

Thus we obtain a molecule composed of aqueous elements which both at the core and all over the surface is *mailed* in oxygen,—nay, oxygen already in union with hydrogen, and that hydrogen so fixed or *nailed* into the atom of aq that it cannot readily lapse along with the oxygen with which it is in union into aq. Such a molecule, then, is secure from the further attacks of oxygen. It must also possess considerable stability. Moreover, its whole surface is adapted for receiving into union with itself, or for going into union with elements of the pentagonal order of forms, such as carbon, nitrogen, phosphorus, &c. It is truly a subhydrate of oxide of hydrogen in the molecular state.

Living or Flowing Water (see Pl. I. fig. XVI. AQ).—If, again, the two atoms of aq on the poles of the tetratom have not been transformed into HO, but continue in the form of aq, so as to give as the hexatom $aqaq^4aq$, the molecule resulting must be entirely different. In this case what is to be expected is a composite hexatom, in which six hexatoms place themselves around a common axis, with their axes parallel to that common axis. But, this done, it is further to be expected that the six atoms of the poles will rush together to form poles for the whole combination, while the remaining four atoms in each of the hexatoms will unfold themselves in a linear series between the two poles, and so that all shall be exquisitely unified, symmetrised, and spherified into an exquisite aqueous capsule, which will be spherical or spheroidal, prolate or oblate, according to the temperature, thus displaying curious changes of volume with changes of temperature, and of which the diagram, AQ (see fig. XVI.), may serve to give some, though a most inadequate, conception. Like the former molecule, it obviously consists of thirty-six atoms of aq; and since it is wholly analogous to the single atom of aq in form, we may designate it by the same letters as capitals.

Perhaps this description of the genesis of AQ is too brief to be intelligible. But there are also other modes of the aggregation of atoms of aq, which must all culminate in this same molecule, and to enter into detail would be unsuitable here. It will easily be discerned by the student himself that such is the laminar form of the atom of aq, that no fewer than 36 are sufficient to admit of that bending round which is necessary to constitute a spherical structure. Nay, he will be willing to admit that such bending round and such a spherical structure are compatible only with a low temperature, and that, too, only when assisted by pressure; for the single atom of aq, morphologically considered, is more perfect as an individualised object than the particle AQ = 36aq. But the weak side of the atom of aq enforces a social nature upon it, and constitutes it a condensing vapour, instead of a permanent gas, and hence we have in nature not dry vapour merely, but moisture and water, and, in a word, a medium and a material for organisation, at least when carbon is applied to assist the weak side, and to render aqueous matter content with the molecular and concrete state.

Thus, according to us, just as the single atom of common vapour is dimorphous, so is the aqueous element in its condensed and liquid state dimorphous. And of the two forms the functioning generally, and specially in the living body, must be extremely different.

The Dimorphism of Aqueous Matter a cause of Animal Heat and Cold.—When they are at the same temperature $(OHaqHO)^{12}$, and AQ must differ not a little as to their capacity for heat. And hence very interesting phenomena must result. Thus AQ is far better suited for entertaining that pulsating or palpitating action wherein heat consists than $(OHAqHO)^{12}$, for in the former all the angles, or at any rate 12 in every atom of aq in the 36 are eminently free to pulsate, while in the latter they are in great measure bound down. Supposing, then, that AQ is an element of water as it exists in outward nature, or as it is taken into the stomach as food when the organism has need of food, and that in the organism it undergoes the transformation from AQ into $(OHaqHO)^{12}$, the loss of capacity of heat which this transformation implies must be accompanied by a considerable disengagement of heat in the region where such transformation is taking place. When, on the contrary, aqueous matter which has been thus transformed is lapsing into common water, that is, when $(OHaqHO)^{12}$ is lapsing into AQ there must be great absorption of heat; there must be coolness, coldness, or chill, and the resulting sweat will tend to be cold.

These phenomena which attach to our physiology I mention here, though out of place, in order to suggest a caution in the discussion of animal heat. At present that phenomenon, and all its differences and variations, are supposed to be explained by combustion taking place in the body between oxygen, carbon, and hydrogen; and it is amusing to observe to what an extent figures may be made to quadrate with that hypothesis. But it explains nothing, or next to nothing, and necessitates a constant reference to the action of the nervous system—the general safety-valve of all pathological hypotheses. From our views of the aqueous element, however (which constitutes not less than three-fourths of the whole body), it appears that its particles are capable of two forms, which must be so dissimilar in their functioning, that, viewed in certain respects, the one, namely, AQ, might be called Living Water; and the other, namely $(OHAqHO)^{12}$, might be called Dead Water,—one very important relation between the two being this, that the former, in being transformed into the latter, gives out its heat. But whether that heat shall go to assist in sustaining the genial glow of healthy action, or to produce inflammation and fever, must depend upon circumstances which we are not now in a condition to inquire into. One thing plainly appears, however, and that is, that the transformation, though excessive, need not be necessarily fatal; for the dead body in this case may be brought to life again, and will indeed revive spontaneously, as soon as it recovers for itself the heat with which it has parted to the surrounding tissue when dying.

But to proceed. Already our attempts at diagrams, by the use of symbols, fail us. We cannot represent anything like AQ with our new symbols. We shall, therefore, not proceed with the synthesis of aqueous elements in detail, further than to say, that in coming so soon as we have done to the two molecules, consisting each of 36aq, we have cut across the course of nature. That course gives successively—

1. *The Azure.*—Perhaps laminæ, or most tenuous world-embracing shells of tetratoms of aq, all poised symmetrically in the sky, but at a distance from each other.

2. *The Serene Cloud.*—Laminæ of vapour, composed of tetratoms more close together, of limited extent, and decussating and interwoven into a cloud-tissue, which we shall afterwards find to be the first type and foreshadowing of organic tissue.

3. *The Rain Cloud.*—When there is a disturbance in the cloud, so that some tetratoms break up, and the single atoms of vapour thus set free go to form the still unbroken tetratoms into hexatoms, the latter, by running into molecules of AQ, would give rain.

4. *Vesicular Vapour.*—An indefinite number of hexagonal forms, when symmetrically adjusted to each other, tend to form laminæ of indefinite extent, and not individualised groups. But under the law of individuation, of symmetry and sphericity, tetratoms of vapour, like single atoms, may form into a spherical group, constituting a finestrated vesicle of exquisite tenuity, an ærial balloon of vapour consisting of a definite quantity of vapour.

5. *The Rain Drop.*—And when these vesicles are disturbed, so that some are broken up into single atoms of vapour, while others survive, the

atoms of vapour set free will go to place themselves on the poles of the tetratoms constituting the vesicles, thus loading these vesicles, so that they may be expected to condense. Now, when they do so, each vesicle thus loaded must give a differentiated dodecatom of AQ. And in this we arrive at the true natural unit of water, whether falling through the atmosphere, or resting in the fountain, the lake, or the ocean. We may thus in symbol represent it—

$$\text{The Rain Drop,}\quad AQ(\overset{12}{AQ})AQ = AQ\begin{matrix} AQ^3AQ^3 \\ \\ AQ^3AQ^3 \end{matrix}AQ = 14AQ = 504aq$$

This, as we shall afterwards find, when the least particle of chloride of sodium which is symmetrical and capable of existing by itself (that is $ClNa^2Cl$ or $NaCl^2Na$), is introduced into its hollow interior, constitutes a unit of sea water. And when urea occupies the same position it constitutes that liquid which Nature supplies at the opposite end of her action. Thus, the best experiments in the most open sea give the quantity of chloride of sodium to water (and the other ingredients are in comparatively small quantity), at about 2·5 per cent.; and our saline molecule, which neglects those other salts, which in small quantity substitute chloride of sodium, gives

$$\text{Sea Water,}\quad \begin{cases} AQ(\overset{12}{AQ})AQ = 22680 = 97{\cdot}48\ldots\text{Water.} \\ Cl\overset{2}{Na}Cl \quad = \quad 586 = 2{\cdot}52\ldots\text{Salt.} \end{cases}\quad \text{(per cent.)}$$

As to urine, the normal quantity of urea is estimated at the same percentage; and as the atomic weight of table salt and urea (when both Na and Cl are estimated at their full) are the same, this implies the same molecular structure. But the atom of urea is symmetrical by itself. In the centre of the aqueous molecule there may, therefore, possibly be only one atom of urea, and this appears to be the case in healthy reposing children; there may, however, be two; but of these things hereafter.

The Ice Molecule.—When, instead of an element of salt or of urea, another particle of AQ gains the interior, the aqueous medium tends to concrete. The molecule, composed of 15AQ, acquires a true unity which it had not when existing as 14AQ, that is, in the liquid or living state. Consequently, under the law of volumes, it now occupies 16 instead of 15 aqueous volumes, the latter number being incompatible with that law of volumes which allows only of the simplest ratios—namely, $1 : \frac{1}{2} : 4 : 8 : 16$, &c. Thus we obtain the specific gravity of ice—

$$\text{Ice}\ldots G = \frac{15AQ}{16AQ} = \frac{15}{16} = .9375 \text{ Exp. } 94 \pm$$

Since the poles are beautifully hexagonal, we also see why ice should give those beautiful hexagonal forms which the snowflake, hoar-frost, and ice-crystals display, as also those beautiful dendritic forms on the windows with angles everywhere of 60° and 120°. Moreover, since adjacent ice molecules may not merely touch each other, but to a certain extent lock into each other at the points of contact, we see also how ice must be capable of regelation, and how glaciers may move down valleys as if the ice were plastic.

But all these things by the way and in haste. In this chapter I only proposed to show the atomic weight of the unit volume of water and of ice, which are the unities in the table of specific gravities, namely,

$$\text{Unit volume of water, } AQ = 36 \times 45 = 1620 = 324, \text{ when } H = 1$$

$$\text{Unit volume of ice,} \quad \begin{array}{ccc} & \overset{3}{A}Q \quad \overset{3}{A}Q & \\ AQ & AQ & AQ \\ & \underset{3}{AQ} \quad \underset{3}{AQ} & \end{array} = 16\ AQ$$

Fluoric Moisture.—At this part of our molecular morphology as the opposite pole, fluoric vapour and moisture present themselves. As the heaven-descended aqueous element tends to supply and conserve the siliceous crust of the globe, so does the fluoric element tend to dissolve it. But so little is known of this destructive agent that a verification of our theory of it is an elaborate investigation which it would be quite unsuitable to enter upon here.

But it may be mentioned that the baric oxygen which our theory calls upon us to seek for (see p. 6), leads us to fluorine. Thus, given an unit of baric oxygen gas, then in order to supply its poles with an atom of H in each, as we have seen that the unit of common oxygen gas tends to do, it will not need to wait until free hydrogen come into the ambient. Thus, since the atom of baric oxygen consists of 5Ħ, and each atom of Ħ = 4H, the baric oxygens can supply their own poles with hydrogens from their own interiors. And thus there will result, as an atom of baric oxygen gas, a couple of baric oxygens, the atomic weight of each being—

$$(5 \times 4 \times 5) - 5 = 100 - 5 = 95, \textit{ i.e.}, 19 \text{ when } H = 1,$$

which is the atomic weight of fluorine. Hence—

Baric oxyhydric acid...HOOH = HFFH...Fluohydric acid.

This, however, as might be shown, finds repose in nature only as—

$$\text{Fluor}\ldots G = \frac{FCa(CaF\overset{12}{F}Ca)CaF}{AQ} = \frac{26 \times 195}{1620} = 3{\cdot}14 \text{ Exp. } 3{\cdot}0\ldots3{\cdot}18$$

As to the light oxygen, consisting of 5H, and the barytic oxygen of 5Ħ, which attach to our theory, we have found them; and they are of great interest; but they are not for this place.

CHAPTER V.

ABYSSAL, PLUTONIC, VOLCANIC ACTION, AND ITS SULPHURIC PRODUCTS.

Let us conceive that, in virtue of adequate pressure or otherwise, there is a mass of matter consisting of material elements or units of atomic weight, lying all as near to each other as may be, and at any rate all equally near or equally distant, so that the whole is uniformly dense. And as an analysing or partitioning influence, let us suppose an adequate heat to be awoke in it.

The question is, What are the simplest unified groups or elemental molecules which will be determined in the seething mass or medium, and attain to individuality, and possibly escape in the æriform state, or remain and be found in the concrete mass below, if the fire should abate? To this it is to be immediately answered that there will be found—

The Tetrad (see Pl. I. fig. 1, Δ).—It may be shown that though the analysing force were so powerful as to expand and separate the mass or medium to such a degree that the constituent units should exist in no higher combinations than couples, yet these couples would immediately place themselves crosswise to each other, two and two, the one couple above the other. For, by so placing themselves, they at once satisfy the law of symmetry and sphericity, and out of four units of weight or elemental forces there is constructed a system of four "triangles of forces," a combination whose stability must be insuperable. Now, such a structure is that which we have met with already, and named the tetrad. This, then, we find in the abyss to be the last, as in the sky we found it to be the first, of all molecular elements. It is primal, ultimate, untransformable, monomorphous, and, in a word, the basis of all molecular systems.

And since such is the pre-eminence of the tetrad, in order to keep the conditions of our molecular aggregation as simple as possible, we may assume that in the abyssal region, in so far as there are individualised molecules at all, there are tetrads only. Given the mass or medium in tetrads, then, what shall we have next? To this it is to be answered that, under our ever-operating law of symmetry and sphericity, we shall forthwith have—

The Bitetrad (see Pl. I. fig. II. ♅).—The tetrad, when existing alone, is symmetrical only when viewed in reference to its own centre, or as its own universe. When viewed from any point without itself, that is, as a member in a system, it is as crystallographers have long ago determined only a hemiform. It is a pyramid, a form shaped to rest upon some other form.

The degree of analysis, therefore, conceived in the preceding paragraph, in which the seething mass or medium is supposed to be resolved into tetrads existing singly, is rather to be regarded as a limit than as a reality that will ever exist. However powerfully the analysing and dissociating force may operate, the tetrads, as fast as they are individualised, will clap together, and rest on each other in couples applied base to base. Thus, instead of single tetrads, we obtain the mass or medium as consisting of bitetrads. And in the bitetrad we have a form which, unlike the single tetrad, is capable both of mobility and stability: *mobility*, because it has two poles which are similar to each other, and an equatorial region lying evenly between them, whence it can be actuated by heat (that is, can pulsate or palpitate symmetrically) without self-destruction or transformation; and *stability*, because it is finely differentiated, each angle of the equator consisting of two, and each pole of a single force, whence poles and equator will tend to remain in union, that is, the bitetrad to be conserved; for this is the condition or universally acknowledged law of chemical union and cohesion, namely, the union and subsequent adhesion of dissimilars. No doubt, in the popular chemistry, this law is applied only to entire atoms and molecules when they are dissimilar, whilst we apply it to different parts of the one and same atom or molecule when they are dissimilar. But taking into account our views of the structure of atoms and molecules, this extended, or rather, indeed, this more close application of the law, is obviously legitimate.

We are not, then, to expect the single tetrad to be found as a chemical element, that is, as a kind of matter which can be separated from other kinds of matter, or, if not separated, at any rate moved from union with one kind of matter into union with another kind, so as to render its existence certain, and its properties more or less cognisable.

Single tetrads, whenever they are not permitted to cohere in larger numbers, will in every case cohere as bitetrads. Are we, then, to look for the bitetrad among chemical elements? Have we reason to infer that in such a seething mass or medium as we have now conceived, bitetrads will escape singly out of it, and thus constitute a gaseous medium, and give to nature a certain kind of gas? To this question the proper answer appears to be, that if the heat applied were most intense, bitetrads, in whatever molecular states cohering, might be expected to be dissociated and escape one by one. Now, suppose they did, what should we have? Plainly, we should have a new sort of hydrogen gas, its weight to the true hydrogen as 8 is to 5, and therefore still very light, and having a spectrum which would, no doubt, be analogous to hydrogen, but not identical with it. Those, then, who have learned to clear out the jumble of the natural eyesight by the use of the prism, should study the chromosphere of the sun, with a view to consider whether the view here advanced as to there being possibly two kinds of hydrogen there, may not explain observed phenomena. Perhaps in our own planet, small though it be, and comparatively moderate every known heat, this kind of hydrogen, which for a reason presently to appear we have called hylagen, may also be detected in the proper quarters.

But the structure of the bitetrad leads us rather to expect that bitetrads, when they have been formed in a mass or medium, will not leave that mass or medium one by one, but on the contrary, cohering together in such numbers, and constituting such molecules, as the law of symmetry dictates. This inference is grounded upon the fact, which has been already stated as the ground of the stability of the bitetrad itself, namely, that the equatorial angles of the bitetrad consist each of a couple, and its polar angles of a single unit only. Hence, as possessing dissimilar parts, bitetrads will tend to unite and to cohere poles to equators, thus giving birth in the seething mass or medium to molecules, consisting of such groups of bitetrads as the law of symmetry builds up. This is all the more to be expected, because when thus united, the entire regions of union between the adjacent tetrads must consist of triangles of forces, constituted of the two forces proper to the equator in the one bitetrad, and the one force proper to the pole of the other, which is dragged along and retained in union with it. Thus we see our way to the construction of a system of molecules consisting of triangles of forces, which, therefore, on well-known principles of statics, may be very stable. Their atomic weights, also, must obviously be quite definite; also their favourite combining ratios; for these must be functions of their forms; also their physical properties when investigated on the same principles applied to all. We have, therefore, ample means of verifying the inquiry, whether our bitetradic structures be representatives of the elements known to chemists, or whether they be creatures of fancy merely, which nature refuses to sanction.

What then, let us ask, are the simplest groups of cohering bitetrads which we may expect to be individualised in, and to escape from a material mass or medium existing in the circumstances which we have conceived? To this question we obtain a very definite and surely, it will be admitted, a very remarkable answer. And to find what that answer is, let the candid reader, neglecting the blackfaced letters which are here made to introduce the paragraph for the sake of future reference, read on.

Oxygen and Sulphur.—Neither two, nor three, nor four bitetrads can construct a molecule which shall be symmetrical and mobile, and possibly insulable. Elements possessing the absolute atomic weights of 16, 24, 32, that is, 3·2, 4·8, 5·4, when H = 1 are excluded by the law of symmetry. But five bitetrads can form either of two sorts of symmetrical molecules, both of which have poles, which in the same molecule are similar to each other, as also an equatorial region lying evenly between these poles,—both of which molecules may therefore be possibly both mobile and insulable.

In both, the constituent tetrads cohere poles to equators. But in one (Pl. I. fig. XIII. O) they cohere by their facets. In the other (Pl. I. fig. XVII. S) they cohere by their edges only. And hence there results such a complete difference in form and structure, that these two may be said to be the alternate forms of the same matter.

And here let us remark, that as we have even already found advantage in substituting for the symbol of a single atom of oxygen the numeral 8 in one position or another, so shall we find it of great advantage to adopt as the symbol of this new element, instead of the very complicated form S, some simple form, also in the printer's hands already, such as the double dagger (‡). The analogy of this new element to hydrogen (which we shall find to be very great), will thus be indicated by its symbol, that of hydrogen being the single dagger (†).

But are we to expect either O or S to be usually met with either in Nature or in the laboratory in single atoms? No; the form of the one (O) is very oblate; that of the other (S), is very prolate. The former is altogether in want of matter on its poles. The latter is in want of matter on its equator. If, then, each by entering into union with its own atoms (supposing only one kind to be present), can remedy this defect, it will do it. Now the first, O, can briefly supply this defect by coupling into Ⓞ (see Pl. I. fig. XIV.), and the last, S, can supply its defect when three other atoms of the same plunge into the three vacant spaces in the equator of the first by their poles (see Pl. I. fig. XVIII.), constituting a tetratom = S^4 or 𝕾, for which, when it occurs in a figurate formula, we may substitute—

, or more briefly ✠.

Such, then, are the molecular states of these elements, in which, if such structures exist in nature at all, we are to expect to find them when in the free state.

And here, viewed in this state as compared with that of their genesis, namely, that of single atoms, a very remarkable phenomenon presents itself. Thus we have said that the atom of O, as compared with that of S, is such that they may be regarded as alternate or reciprocal forms of the same matter, the single atom of O being eminently oblate or negative, and the single atom of S eminently prolate or positive. But when O has coupled into ©, it has become much less negative; nay, its dynamisphere overhead may be spherical, so that O in coupled atoms shall no longer display that restlessness or activity which will be inevitable to it when existing in single atoms. And S, when it has quadrupled into S^4, instead of being any longer positive, is as negative as the single atom of O itself. Atoms of S, in arriving at a combination which shall be spherical, have in the first attempt quite passed through the spherical, and given birth to a form having the opposite morphological defect to that which was possessed by them on their genesis. The form of repose has been passed through. The pendulum has swung quite to the other side. And this is a phenomenon which we shall be very frequently meeting with. It is, indeed, that institution by which the molecular life of Nature is mainly sustained, and that universal stereotype to which the principles of statics universally point indefinitely postponed. It will be granted that it is in perfect keeping with all that we see and know of visible nature.

Here, then, in this structure S, we see remarkable morphological, and, consequently, functional powers. In its single state it is analogous to hydrogen, and must function like hydrogen. In its ordinary state it is analogous to oxygen, and must function like oxygen.

But let us proceed no further till we inquire what are the atomic weights of these two elements which thus meet us so early in the seething abyss. In their single state they are obviously the same in weight, and since each consists of $5\mathfrak{H}$, that weight is $5 \times 8 = 40$, that is, 8 when $H = 1$. But in their usual modes of occurrence O, when existing in coupled atoms, as ©, must obviously weigh $2 \times 40 = 80$, *i.e.*, 16, when $H = 1$; and S, when existing in tetratoms, as S^4, must weigh $4 \times 40 = 160$, *i.e.*, 32, when $H = 1$.

Let it not be concluded, however, that at one and the same temperature, whatever that may be, the one shall just weigh double the other in the æriform state. Here, in fact, at comparatively low temperatures, we may expect an experimental verification of what was advanced as mere theory in reference to the tetratom of hydrogen (see p. 16). We may expect that molecules of S^4, in rising into the æriform state, will not rise single, but, on the contrary, each in consequence of its extremely oblate form carrying along with it another in each pole. Thus making the unit volume of

Sulphur vapour......................$S^4S^4S^4$ (see Pl. I. fig. XXI.),

obviously weighing six times that of oxygen gas.

But here the reader may justly complain of my using names which take for granted the very thing to be proved. Surely it will not be denied, however, that even already these molecular structures of atoms represent to a wonderful extent those unknown bodies which go by the name of oxygen and sulphur? How shall the chemist arm himself against the suspicion, at least, that our structures really may represent these bodies, but by throwing this book into the waste-paper basket?

But let us proceed. It is not atomic weights merely which our theory enables us to deduce, but specific gravities also. Thus, we have seen that the unit of water occupying an unit volume of this liquid = AQ $= aq^{36} = 36 \times 45 = 1620$ units of weight. It may also now be seen with regard to S^4 that since it is trigonal in all its dimensions, its molecule must be the icosatom (see Pl. I. fig. V. and p. 8). Supposing, then, that through the unceasing operation of the law of assimilation, the unit of water, AQ, and the molecule of sulphur, $(S^4)^{20}$, have come to be isovoluminous,—a condition towards which we shall find all individualised molecules tend in the concrete and liquid state, no less than in the æriform (which has been long known),—we obtain the equation—

$$\text{Sulphur...G..}\frac{(S^4)^{20}}{AQ} = \frac{20 \times 4 \times 40}{1620} = 1{\cdot}96 \text{ Exp. } 1{\cdot}98...2{\cdot}00.$$

Here, then, is another verification, and one to which the chemistry of the day, which is also that of the dark, is a perfect stranger. If, then, I be not as yet permitted to regard our tetratom S^4 as representing an atom of sulphur, may I not be allowed to designate our single atom S by the name of sulph?

And here another verification. On inspecting minutely the symmetry of our molecule of S^4, it will be perceived that the axes of the three equatorial atoms of S do not lie in the plane of the equator, but all incline to one and the same pole. Hence, in the molecular state, this element must be dimorphous. Both its molecules must, indeed, be icosatoms. But in one of these molecules the acute angles formed by the equatorial elements with the axial elements will be peripherad, in the other they will be centrad. Now, though we are as yet at an immense distance from those resultant forms and forces which must determine the forms and structures of visible objects, such as crystals, yet it is only to be expected that these two kinds of molecules, in constructing crystals, will yield two sorts which shall be unlike each other. Now this is observed in sulphur.

Again, each of these two icosatoms will be proper to a certain temperature, and when the temperature changes through a certain range, the one will change into the other. Now, during the period of change it is only to be expected that many single atoms of S^4 will be set free and exist singly among the icosatoms new and old. Considering, then, their grapnel-like shapes, it is only to be expected that they will prevent the perfect fluidity of the hot substance, and keep it in a viscid state. Now this is known of sulphur.

Sulphuretted Hydrogen, Hydrosulphuric Acid.—Having fallen into a remark on the subject of sulphur in the æriform state, it may be here added, that obviously the proper morphological correction of the very oblate form of the atom of sulphur, so that it may be capable of a fully individualised or æriform existence, is not an atom of sulphur on each pole of a central atom, which manifestly both over-extends and overloads the poles, but an atom of hydrogen only, giving (see Pl. I. fig. XIX.)—

Hydro-sulphuric acid,  $= H\overset{4}{S}H = H_2S_4 = H_2S.$ Auct.

This is, accordingly, the state of union in which sulphur escapes spontaneously into the atmosphere, when bodies which contain it along with hydrogen are undergoing decomposition. Happily it is not inveterately æriform. It may be condensed even in the laboratory, and the liquid has been found to have a density of about ·9, while the solid is heavier, so that we may regard it as about 1. If, considering its great volume, we allow it two aqueous volumes, we obtain—

$$\text{Its Crystals, G...} \ \frac{(H\overset{4}{S}H)^{20}}{2AQ} = \frac{20(5+160+5)}{20 \times 1620} = 1{\cdot}05 \text{ Exp. } {\cdot}9 \ldots 1\,.$$

But we have now to consider sulphur, not in relation to hydrogen, but to oxygen, which we regarded as formed in the abyss along with it, or rather, indeed, before it.

Sulphurous Acid.—And here a very beautiful structure presents itself, though, considering the demand of H and O when they meet to lapse into aq, it is not easy to believe that it is ever constructed in the rapid and rude processes of the laboratory. The tetratom of sulphur, which forms the body in the atom of sulphuretted hydrogen (see Pl. I. fig. XIX.), has three sulphic arms, which stand out from the axis naked, while yet, from their dissimilarity to oxygen, they must tend to be covered or capped by this universal parasite. If, then, the oxygen present do not first carry off the hydrogens of the poles, and lapse along with them into moisture, we may possibly have a sulphuretted hydrogen or hydrosulphuric acid, its equatorial region mailed in oxygen. Its formula must be that of the sulphurous acid of the unitary chemistry, and a very fine acid it must be.

$$\text{Sulphurous Acid, } 888 \overset{\ddagger}{\underset{\ddagger}{\maltese}} 888 = H_2\overset{4}{S}Ⓞ_3 = H_2SO_3. \text{ Auct.}$$

But if we are uncertain about admitting this beautiful acid as a chemical, there is another which obtrudes itself upon us, though only in a transient way, yet as most certain, and, as we shall find, justly entitled to the name of an acid, though it be not "a salt of hydrogen."

Thus the forms of S and O are no less dissimilar to each other than those of H and O, to which they are, in fact, highly analogous. Given an atom of S, then, to an atom of O, they will unite, as H and O unite. But while HO lapses in aq, SO can experience no such change. The single atom of SO is, however, dissymmetrical, and cannot exist in the free state. But it is to be remembered that oxygen does not exist in the free state in single atoms, but in doubled atoms. What we are to expect in nature, then, is not SO in single atoms, but in coupled atoms. Now, these are symmetrical, and may exist in the free state. They obviously consist of equal weights of sulphur and oxygen—

$$\text{Sulphous Acid, } \overset{\ddagger}{\underset{\ddagger}{88}} = SⓄS = SO_2. \text{ Auct.}$$

Now, here we have an æriform element whose poles are trigonal or lance-shaped, the same as if they were atoms of hydrogen; and beneath these poles there is oxygen. Since, therefore, such a molecular structure in the case of hydrogen implies acidity, we infer that this is an acid, that is, it will change vegetable blues to red, and have a taste which, unless covered by some stronger taste, will be more or less sour.

But such a molecule is in a high degree prolate. Under the law of symmetry and sphericity, its axis is much too long for its equator. May it not, then, by doubling, or else by dedoubling, improve its condition in this respect? Plainly, it may do so by doubling. The four atoms of S, in two atoms of SⓄS, may assume the molecular state of S^4, which may become the body of a doubled molecule, while the atoms of Ⓞ will betake themselves one to each pole. Thus we shall have—

$$\text{Sulphurous Gas, } \overset{88}{\underset{88}{\maltese}} = Ⓞ\overset{4}{S}Ⓞ = SO_2. \text{ Auct.}$$

Here, then, we have another æriform element more stable than the last, not only in consequence of being more spherical, but in consequence of having its poles capped by oxygen, and consequently protected from the further attacks of that corroder. Like SO and SⓄS, it consists of equal weights of sulphur and oxygen; and if, when in the æriform state, each unit of oxygen gas retains its own volume, and the intermediate atom of sulphur lie between, its sp. gr. will obviously be double that of oxygen gas; as is the case with sulphurous gas.

It must differ now, however, materially in its functioning from what it did before it doubled. It is now no longer an acid. It is rather a deutoxide, with the terminal or peripheral atom of oxygen only loosely engaged. Instead of reddening vegetable blues, it may, therefore, be expected to bleach vegetable colours, and perform those offices generally which result from the impartation to coloured substances of oxygen in single atoms, that is, oxygen in the most active state. But in doing so it must lose the æriform state, and then, doubtless, an acid form will soon again appear.

If from the first the æriform state should be forbidden, or if by cold, or pressure, or both, it should be abolished, there would then result this substance in the molecules proper to its element, SO. Now, of that element one pole is pentagonal, and the other is trigonal. Its molecule may, therefore, be either the dodecatom or the icosatom. And when fully differentiated and most stable in structure, a mass may consist either of dodecatoms and of icosatoms in equal numbers, or of the one sort as a nucleus, and the other circumscribing it according to the law of symmetry, which expresses the relations of these two polyhedrons as long since set forth by geometricians. In either case, we obtain, as the equation of specific gravity—

$$\text{Concrete Sulphous Acid, } \frac{(SO)^{12+20}}{AQ} = \frac{32 \times 80}{1620} = 1{\cdot}58. \text{ Exp. ?}$$

Now, sulphurous gas has been forced down into a liquid, and that has been solidified. The specific gravity of the liquid has been found to be 1·45, and that of the solid heavier. And, altogether, may we not fairly ask whether these views of this substance do not go much farther than all the knowledge that we otherwise possess in explaining the seemingly anomalous properties of the first products of burning sulphur.

In our theory nascent sulphurous, or sulphous acid, SO, is the homologue of HO, and in its genetic power it is scarcely less important. It is the beginning of mineral nature, as HO is the beginning of organic nature.

And here it will be legitimately asked, If SO be analogous to HO, are we not, then, on the access of moisture to the fumes of burning sulphur, to expect that—

Hydrous Sulphous Acid, OSaqSO =  the homologue of  = OHaqHO (see p. 22).

as also that the aqueo-sulphous combination shall possess greater stability than the purely aqueous?

To this it is to be answered, that immediately sulphurous fumes are admitted to water, this appears to be the combination which is first constructed, and it has been obtained in cubical crystals. Its unitary formula is H_2SO_3, which, contrary to what is usual, is the double of what it ought to be, and which we have seen to represent a very different substance (see p. 35).

But not the nascent sulphous acid, but the full bodied sulphurous acid also combines with water, and in this case not with moisture merely, but with water in particles. Thus when moist sulphurous fumes are passed through a freezing mixture, nitre-like crystals are obtained, having the seemingly strange formula, $SO_2.9H_2O$. Now, when this is unravelled and doubled (as is usually necessary with chemical formulæ, because they are cut to a single polar element as the controlling substance, instead of two, as ought to be), we obtain simply a particle of water aq^{36}, with an atom of mature sulphurous gas, ◎S◎, on each pole,—the form of the particles of water being, no doubt, $(OHaqHO)^{12}$, so that the whole is a differentiated dodecatom—

The Nitre-like Crystals, $◎\overset{4}{S}◎(OH\overset{12}{aq}HO)◎\overset{4}{S}◎ \;=\; 2(SO_2.9H_2O)$.

It is to the nascent hydrate, however, that the chief interest attaches. These things, therefore, we hurry over, leaving it to the reader's candour to observe how many seeming arbitrary phenomena of the laboratory they explain.

Sulphous changes into Sulphic Acid (Pl. I. fig. xx.)—In the hydrous sulphous acid, OSaqSO, the axis under the law of sphericity is obviously much too long. The poles are also obviously overloaded by the oxygens which they carry. A transformation may, therefore, be expected, and a translation of the polar oxygens to the equator. But the polar oxygens are only two in number, while the symmetry of the hexagonal equator demands three oxygens, one on each alternate segment of the atom of aq. What is wanted, then, and all that is wanted in order to the accomplishment of this transformation, is the supply of a third atom of oxygen. Now this, nature is ever ready to supply in many ways; and this it is which art makes its point to supply in the usual method of converting the fumes of burning sulphur into oil of vitriol by the use of nitre. Thus sulphous becomes sulphic acid according to the equation—

$$SO_2HO + O = \begin{matrix}\infty\\ +\\ +\\ \ast\\ +\\ +\\ \infty\end{matrix} + \infty \;=\; \begin{matrix}+\\ +\\ \infty\ast\infty^2\\ +\\ +\end{matrix} = SO_3HO.$$

Moist sulphurous acid and oxygen. Oil of vitriol.

But of these things hereafter. Here let us rather consider the course of nature in fixing the fumes of burning sulphur without partitionment of the sulphur.

Sulphates, or rather Sulphurates.—In the atom of sulphurous gas (©$©, p. 35), it has been stated that the terminal atoms of oxygen are only loosely attached, and in excess of what is needed there, while the three sulphic arms of the equator are naked and in want of oxygen. A change, therefore, in the distribution of the oxygen may be expected. But in order to effect such a change consistently with the law of symmetry, a larger supply of oxygen is required. In a word, what is wanted to impart a true stability to the combination is the differentiation of it by the introduction of metallic matter in the axis and the capping (so as to protect from the further attacks of oxygen), the three naked equatorial sulphic arms, by oxygens.

Instead of the coupled atom of oxygen, then, on each pole, let us substitute for one of the atoms of this non-metallic element some metallic element which we may denote by the symbol X, letting the remaining atom of oxygen be ultimately terminal; and let us add, as has been purposed, three coupled oxygens on the three sulphic arms; and then, undoubtedly, we shall have a structure which is finely differentiated, being composed in part of non-metallic, metalloidal, and metallic elements; which it is protected both on the equator and the poles from the further attacks of the oxygen of the world; and which overhead, may, in point of general form, be regarded as spherical. Our figurate formula is but a poor representative of such a structure; yet even by inspecting that formula these things appear; as also that its composition is that of one atom of a Sulphate, which we, however, must call

∞
X
A Sulphurate, 888✠888 = OX$XO = M_2SO_4. Auct.
X
∞

When such a structure is considered, it will be seen that its stability cannot but be great. There are many such in nature. And here we may mention three which are products of the action which we are now considering, the first of which, indeed, we might have constructed in detail but for the lengthened investigation which it required. They are all three, isomorphs—the first common, the second baric, and the third barytic. Supposing that their molecules are all the differentiated dodecatom, which is by far the most abundant in the crust of the earth, we obtain their specific gravity thus—

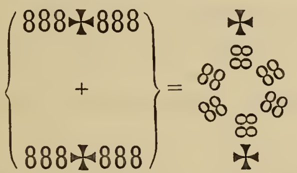
Anhydrite,........G $= (\dot{\mathrm{Ca}}\mathrm{S}\dot{\mathrm{Ca}})^{1+12+1} = 2{\cdot}95$ Exp. $2{\cdot}90$.

Celestine,..........G $= (\dot{\mathrm{Sr}}\mathrm{S}\dot{\mathrm{Sr}})^{1+12+1} = 3{\cdot}97$ Exp. $3{\cdot}95$.

Barytes,............G $= (\dot{\mathrm{Ba}}\mathrm{S}\dot{\mathrm{Ba}})^{1+12+1} = 4{\cdot}64$ Exp. $4{\cdot}70$.

The higher synthesis which takes place in organic nature succeeds not unfrequently in doubling the sulphuric structure which forms the body of these mineral elements. This also appears to be frequently effected by the chemist. Hence—

Sulphuric Acid.—The combination SO_3, that is, sulphuric acid commonly so called, possesses a form so oblate, that if more than one such element were ever neighbours in the free state, they would certainly unite in couples; for in that case there would result a beautifully differentiated dodecatom consisting wholly of oxygen, with an atom of sulphur on each pole. It appears to exist in the taurocholate of the bile and elsewhere in nature. The chemist also has succeeded in obtaining it, though always in a very impatient state.

Sulphuric Acid,  $= \overset{4}{S}\overset{12}{O}\overset{4}{S} = 2SO_3$. Auct.

Here in the figurate formula on the right hand, representing the element of anhydrous sulphuric acid or sulphuric anhydride, that element is represented as a differentiated dodecatom, the body composed of twelve atoms of oxygen, the poles consisting of an atom of sulphur each. But it must not be inferred that that formula gives an accurate idea of the structure. Thus it represents the body of the molecule as double-walled. Now, this is not the case. It requires twelve atoms of a pentagonal form, such as oxygen, to complete the dodecatom all round. To make it double-walled twenty-four are required. The only advantage gained by giving the formula as has been here done, is that, by simply counting the constituent elements, we can immediately ascertain their actual number. As a general rule, however, it will be better to content ourselves as to this point by looking to the numerals in the literal formula, and to construct our figurate formulæ as disks of molecules merely, giving generally, indeed, all the elements in the axis of the molecule, but as to the body of the molecule, giving only two of the radial parts on each side instead of all the ten.

As to the specific gravity of sulphuric anhydride, it appears to attain to a normal volume, when the first group in the trigonal series of regular polyhedra has been constructed instead of the last, that is, when the tetratom has been constructed instead of the icosatom—a state of things which we shall afterwards find in the case of nitric acid, &c. Thus—

$$\text{Sulphuric Acid, } \frac{(\overset{4}{S}\overset{12}{O}\overset{4}{S})^4}{AQ} = \frac{4(160+480+160)}{1620} = 1{\cdot}97 \text{ Exp. } 1{\cdot}95 \ldots 197 .$$

Sulphic Acid—Oil of Vitriol (Pl. I. fig. xx.)—It is obviously only under very peculiar circumstances that such a molecule as the sulphuric anhydride just described could be constructed and conserved in this terraqueous globe where moisture exists everywhere. Let such a molecule (especially if it has been obtained by the expulsion of water) be exposed to the access of moisture, and a rush of the latter may be expected to both poles. Now, each pole being a tetratom of sulph, and having four summits, free and terminal, will immediately fix four atoms of aq, and there will result at the moment

$$\text{Hydrated Sulphuric Acid, } (aq\overset{4}{S})\overset{12}{O}(\overset{4}{S}aq) .$$

But now the structure has become so wanting in unity that its longer cohesion may be suspected, especially as the sulphur poles, by opening up into single atoms of sulph, and distributing among themselves the water and the oxygen, may give rise to a new molecular species of exquisite structure and symmetry. In a word, we may have the equation—

$$(aq\overset{4}{S})\overset{12}{O}(\overset{4}{S}aq) = 4Sa\overset{:}{\underset{\cdot}{q}}Saq = 4.(SO_3 2HO). \quad \text{Auct.}$$

We thus obtain—

$$\text{Glacial Oil of Vitriol, } \infty \ast \infty^2 = aqSa\overset{:}{\underset{\cdot}{q}}S = SO_3 + 2HO. \quad \text{Auct.}$$

Now this structure is dissymmetrical. It is, therefore, not capable of existing alone in the free state. Such elements, when they exist in the same region, will hurry together into the molecular state. And as neither pole is pentagonal, but one hexagonal or aqueous, and the other trigonal or sulphic, we may expect them to form around either the one or the other, and we may say the latter when the molecule is to be most stable. We may expect the molecule, therefore, when most stable, as, for instance, when it has withstood a severe ordeal such as long continued ebullition, to be the icosatom like that of sulphur itself. We shall thus have, as the equation for its specific gravity—

$$\text{The Glacial Acid, } G = \frac{(aqSa\overset{:}{\underset{\cdot}{q}}S)^{20}}{2AQ} = \frac{20(45+245)}{2 \times 1620} = 1{\cdot}79 \text{ Exp. } 1{\cdot}75 .$$

Here, then, as usual, we are able to deduce the specific gravity as nearly as is to be desired—for the second decimal place depends on the temperature.

But it is obvious that our glacial sulphic structure may also form into molecules with the hexagonal or aqueous pole centrad, in which case the molecule, instead of consisting of twenty, must consist of thirty-six members. Can we then obtain any evidence of this? To this it is to be answered, that plainly it is not in high temperatures that we are to look for such a molecule. Neither are we to look for sulphic acid in nature in its active undifferentiated state. We are to look for it in union with some metallic oxide. Let us, then, suppose a molecule of the glacial sulphic acid, with its aqueous pole centrad to be formed in the cool of nature, and let us encrust it all over with oxide of calcium or lime, the oxygen of the lime on the periphery of the molecule, and we shall obtain a combination which must be neutral, and, up to a certain temperature, stable. Now, as to composition, this is obviously that of gypsum or selenite; and since it is so large and heavy, let us allow it four normal or aqueous volumes, and see what its equation of density gives us.

$$\text{Selenite, G}\ldots\frac{(\dot{\text{C}}\text{aSaqSaq})^{36}}{4\text{AQ}}=\frac{36(140+290)}{4\text{AQ}}=2{\cdot}39\ \text{Exp. } 2{\cdot}3\ldots2{\cdot}4\,.$$

Hence we are easily able to understand how this substance should be so abundant in nature that scarce any land, scarce any fountain, but contains more or less of it. Hence, also, we are able to see why anhydrite, secularly exposed to moisture, must be transformed into gypsum and selenite.

But returning to the laboratory, may not a stronger oil of vitriol than the glacial acid be obtained by longer continued ebullition? The glacial molecule is still moist all over. May not that surface-moisture be completely driven off by boiling? To this it is to be answered, that the best chemists have found that they could not wholly drive off the second atom of water. Nay, curiously enough, that when they have done their best in this direction there still remains about $\frac{1}{12}$th of an atom of water for every atom of monohydrated acid. This seems a very capricious result. But in the light of our molecular morphology, does it not beautifully explain itself? Thus, an atom of water has just twelve summits or points of adhesion for such a structure as an atom of oil of vitriol. What, then, more likely that when the heat and the boiling have been urged in a way which the icosatom of the glacial acid can no longer endure, that molecule, when broken up, shall distribute its elements around atoms of water as nuclei, twelve of them fixed on every atom of aq. This would explain the phenomenon of residuary water found by Marignac, &c. But let us test this theory as usual by deducing the specific gravity—

$$\text{Strongest Oil of Vitriol, G...} \quad \frac{(\overset{\vdots}{\underset{\cdot}{\text{SaqS}}})^{12} + \text{aq}}{\text{AQ}} = \frac{(12 \times 245) + 45}{1620} = 1{\cdot}843 \text{ Exp. } 1{\cdot}843.$$

The power of oil of vitriol of uniting with water, and of detaining it in the liquid state in opposition to its tendency to spontaneous evaporation, is very great, and many are the interesting hydrates which may be produced.

Thus, when exposed a sufficient length of time in a moist atmosphere, instead of *a single atom* of vapour attaching itself to every element of the sulphic molecule, as in the glacial acid, a *particle* of water does so, the whole molecule being thus enclosed in a liquid sphere, consisting of as many particles of water as the molecule consists of elements of oil of vitriol. This implies that a quantity of oil of vitriol, when exposed to a damp atmosphere, increases its weight between six and seven times (as found by Newmans), and is reduced so as to contain only 13·13 per cent. of acid.

The ultimate hydrate (which possesses an organic structure also), is, when a single element of acid lies as a nucleus or axis in the centre of a differentiated dodecatom of water, which implies no more then 1·07 per cent. of acid. And this is certainly the hydrate which ought to be used for therapeutic purposes. But it remains to be ascertained whether the icosatomic molecules can be broken up or digested in water; and, consequently, whether such a hydrate as this can be prepared. That they can, by boiling till the density of the liquid reaches 1·843, has been shown. Perhaps by swamping acid of this density with water the reconstruction of icosatomic molecules might be prevented.

Sulphides and Sulphurides.—As the Plutonic element, which we are now considering, is intermediate in form and structure between non-metallic on the one hand, and metallic on the other, it unites readily with both classes of substances. And here it is interesting to observe, that as nature gives both sulphic and sulphuric oxides, so does it also give metallic sulphides and sulphurides. This we are able to ascertain for certain by applying the test of specific gravity.

Thus, if we take one element of sulphur vapour (Pl. I. fig. XXI.), and conceive it to exist in the free state secularly, while the law of symmetry and sphericity is taking secular effect upon it, the ultimate issue must be the spherifying of its over-extended and over-loaded poles; in a word, the transformation of S^4, which is 4♅_5 into ♅_{20}, that is, as might be shown, the ultimate substitution for an atom of sulphur of an atom of the crackling combustible metal zinc, thus giving ultimately to nature, instead of an indefinite continuance of sulphur vapour, an element of blende (Pl. I. fig. XXII.) Now, supposing this beautiful structure to concrete, as usual, in differentiated dodecatoms, each occupying a normal volume, we obtain, as the equation of its density—

$$\text{Sulphuride of Zinc, G}\ldots\frac{(\text{Zn}\overset{4}{\text{S}}\text{Zn})^{1+12+1}}{\text{AQ}} = \frac{14(160+160+160)}{1620} = 4{\cdot}15 \text{ Exp. } 4{\cdot}16\,.$$

Blende thus contains an atom of sulphur, and is a sulphuride or sulphuret. But that all combinations of metals with this element are not so is shown by another beautiful mineral, galena. Thus the specific gravity of galena is known to be 7·4. Now, either the formula PbS^4Pb, or SPbS, suits equally well the conditions of the analysis of galena. But the former having pentagonal poles, must form into dodecatomic molecules. Now these, if differentiated as usual, would give,

$$\text{G}\ldots\frac{(\text{Pb}\overset{4}{\text{S}}\text{Pb})^{1+12+1}}{\text{AQ}} = 10{\cdot}34, \text{ or possibly } 5{\cdot}17 \text{ if occupying two volumes.}$$

But of SPbS, both poles being trigonal, the molecule must be the icosatom. Now, trying this, we obtain—

$$\text{Sulphide of Lead, }\frac{(\text{SPbS})^{20}}{\text{AQ}} = \frac{20(40+520+40)}{1620} = 7{\cdot}4 \text{ Exp. } 7{\cdot}4\,.$$

Let these remarks, then, suffice on the most interesting but very formidable element, sulphur, which meets us so early in our research. I suppose chemists, notwithstanding their present contempt, will be obliged to look into these matters by-and-by.

Selenium, Tellurium.—The possible occurrence, in regions of great compression, either past or present, of tetradic tetrads, or tetrads each of whose four angles consists of four material units, instead of one only, as has been already explained, leads us to look in nature for two other isomorphs of sulphur—one composed of baric hydrogens, and the other of baric hylagens, instead of common hydrogen and hylagen. As to a sulphur-form composed of common hydrogen, indeed, it is not known, nor need we expect to find in the free state, at the surface of so small a planet as ours, an element the cohesion of whose parts must be so slender as this. But including it in the series, for the sake of completeness, our molecular morphology gives us as the sulphic series of forms the four following, to which, in the last column, I have added names of elements from the common tables which have the same atomic weights.

		Structure.				H = 1	
Light Sulphur,	4 {	5 H	=	100	=	20	(Phosphur.)
Common do.		5 ♅	=	160	=	32	Sulphur.
Baric do.		5 **H**	=	400	=	80	Selenium.
Barytic do.		5 **♅**	=	640	=	128	Tellurium.

The third is four times the weight of the first, and the fourth four times that of the second. As to the fact that the experimentally determined atomic weight of selenium is usually given at 79·5, instead of 80, this is in no degeee adverse to our views. From all molecules, and especially from baric and barytic elements, single, and sometimes even several, units are apt to go off, and so to be missing when the substance comes to be weighed. In the state of vapour, when hot enough to exist as S^4, Se^4, and Te^4, their densities are, as nearly as could be expressed in the theoretic ratios, thus—

	Exp.	Theory.	
Sulphur vapour, ...	2·23	2·25 . .	8
Selenium vapour, ...	5·68	5·6 . .	20
Tellurium vapour, . . .	9·00	9·0 . .	32

Also in the concrete state, could they attain, as sulphur does, to the molecule of culmination, that is, the icosatom, the density of selenium should be 4·92. Now, it has been found 4·8, indicating a mixing in the mass of lesser molecules. Tellurium in icosatoms should weigh 7·88. But this rare substance has, as yet, been found only with a density of 6·32, the structure of the molecule giving which need not be set down, as experiment is wanting.

And here, though it is insupportably tedious, and wasteful of type, to be reminding the reader of every verification as it presents itself, may I not ask whether, in this view of the nature of selenium and tellurium, we have not as perfect a theory of these rare substances, and of their relation to sulphur, as could be desired? And if it be found that this is not a solitary case, but that other groups of substances, similarly analogous among themselves,—such as chlorine, bromine, and iodine; potassium, rubidium, and cæsium; calcium, strontium, and barium; phosphorus, arsenic, vanadium, antimony, bismuth—are also similarly common, baric and barytic, or mixed isomophs of the same structures, there must be something in these views which is more than mere imagination. Besides, let the reader be as blind as he finds himself to all the insight and beauty which appears to the author to belong to the theory of molecular nature, which is here unfolded, and as averse to every attack on the existing philosophy of chemistry as he may be, what is to be made of our deduced specific gravities?

It is said in opposition to such a view of the nature of oxygen and sulphur, that both these elements are undecomposable and simple, while these structures of ours are molecular, and ought to be decomposable. The answer is, that oxygen and sulphur have been found to be undecomposable only under a certain ordeal, that, namely, of the chemist's laboratory. But that ordeal, when compared with Plutonic or abyssal volcanic fire, is as nothing. Now, oxygen and sulphur, before they have come into the hands of the chemist at all, have withstood and escaped undecomposed from the Plutonic action and the volcano. Surely, then, they are not to be expected to break up in the hands of the chemist! The inference that the particles of bodies are undecomposable in their own nature and simple, because chemists have not hitherto succeeded in decomposing them, is a manifest fallacy, which it is wonderful that it should ever have obtained the currency which it has obtained. Is it said that such an inference is a legitimate induction, and that the soundness of the inductive logic is not to be questioned? Be it so. That same logic on this occasion presents to us a set-off against itself,—a set-off which leads distinctly to the inference, that comparatively heavy elements, such as oxygen gas and sulphur, are not undecomposable in their own nature, though chemists, in the present confessedly imperfect and advancing state of their art, may not be able to decompose them. Thus, as the analytical apparatus of the laboratory has been improved, more and more substances, previously found to be undecomposable, have yielded to decomposition; so that now out of many thousands only between sixty and seventy resist. Does not the inductive logic, then, call upon us to infer that as our analytical appliances are further improved, more and more of these residuary substances will yield also, and among these oxygen and sulphur perhaps? Thus, this popular logic contradicts and so corrects itself. But it were a better use of it to say, that since man, with his merely mimic appliances, and his merely momentary experiments, can decompose or transform so many of the particles of bodies, it is only to be expected that Nature, with her tremendous forces operating during untold ages, will decompose or transform them all,—ever providing that the form and structure of each shall always be in statical harmony with the dynamical conditions of its existence.

CHAPTER VI.

THE ALKALIES AND ALKALINE EARTHS.

It has been supposed that oxygen might possibly be constructed in the seething abyss of bitetrads, and escape in a free and uncombined state. But in all ordinary circumstances, at least, it is obvious that this is not to be expected. It is obvious, on the contrary, that in all ordinary circumstances the empty hollow poles of every atom of oxygen, as fast as that atom is formed, will be packed with the bitetrads which are swarming all around; for each hollow oxygen pole is precisely a mould for five bitetrads when united by a terminal edge in each as a common axis for all (see Pl. II. fig. I. ♉). What we are to expect, then, in the abyss in the first instance, is not oxygen in the pure or free state, but oxygen with atoms of this new element, packed and welded into its poles (see Pl. II. fig. II. Na).

Magnesium, Calcium, Strontium, Barium.—When oxygen is still scarce, we may also expect this new element, ♉, doubled in each pole of the medial atom of oxygen; for in this new element the metallic or five-fid pole is also a mould for its own metalloidal or lens-shaped pole, as well as for the poles of oxygen. We shall thus have—

ʿNa...  and  ...ʿK (see Pl. II. figs. II. and III.)

Now both these may be expected to be undecomposable in the laboratory —(1.) Because the medial element, oxygen, is such a perfect coupling joint for the polar elements; (2.) Because both a single and double atom of ♉, such as exists in ʿK, is dissymmetrical and heteropolar, and incapable of separate existence; and (3.) Because where the axis of a molecular structure, when compared with the equatorial diameter, is, so long as in these elements there must exist, under the law of sphericity, a powerful force in the axis to shorten it, and, consequently, to press and weld all the constituent parts together.

But these new structures are not to be expected to be found in nature in this naked state. As has been shown elsewhere at length (see A Sketch, &c., Part II. p. 76), such five-fid poles are metallic, while oxygen is wholly non-metallic. As atoms of the latter, then, are further developed in the abyss, they will, in virtue of their dissimilarity to the newly constructed metallic elements, unite and cover their metallic poles, and thus secure our new structures from the further attacks of oxygen (in virtue of the repulsion which exists between identicals). We shall thus obtain—

(OṄaO)  and  (OK̇O).

And in these structures we see a great degree of symmetry along with admirable differentiation, and a complete protection from the further attacks of oxygen, the distribution of that element in the structures being perfect already. Thus, there is one atom in the equator and one on each pole. And such, generally, is the perfection which attaches to the "sesquioxide," a combination which exists in nature to a far greater extent than is commonly observed.

But both these structures, especially that with double polar elements, have the great fault of existing in opposition to the law of sphericity; the axis in both, especially the latter, being much too long for the equatorial diameter. When, therefore, they exist in the æriform state, or single, or are anyhow prevented from placing themselves as radii in an isometrical molecule, they will tend to dedouble, or part into two, at the equator; so that when halved, each half may be more nearly spherical than the whole.

In order to success in dedoubling, however, these two conditions are necessary—(1.) The equatorial element must be capable of opening up symmetrically; and, (2.) Each half, when separate, must be symmetrical on both sides of its own equator. Now, both these conditions may be here fulfilled. The equatorial element in both is an atom of oxygen; and though we have hitherto viewed the atom of oxygen as consisting of five bitetrads leaning on each other face to face, yet it may be equally viewed as consisting of two coronet-shaped elements (see Pl. II. fig. IV. Be), each composed of five tetrards, and both locked into each other. And it may be shown that into two such coronet-shaped elements, the atom of oxygen, in its secular transformation from the non-metallic into the metallic, tends to unlock and dedouble.

Our two metallic elements, then, ʻNa and ʻK, in the circumstances stated, will dedouble, and will be transformed into two new elements, both the poles in each similar to the other, and both elements similar to each other, only that the one—namely, that resulting from the dedoubling of ʽK—will have a longer axis than the other, corresponding to its greater atomic weight.

As to their atomic weight, it will obviously be in

$$\frac{ʽNa}{2} = \frac{40+40+40}{2} = 60, \textit{ i.e.} = 12, \text{ when } H = 1 = Mg.$$

And it will be in

$$\frac{ʽK}{2} = \frac{40+40+40+40+40}{2} = 100, \textit{ i.e.} = 20, \text{ when } H = 1 = Ca.$$

Our elements obtained by the dedoubling, then, of ʽNa and ʽK have the atomic weights of magnesium and calcium.

Further, as to their specific gravities. Supposing that under the law of redintegration being dedoubled elements, they tend to go in couples, when forming into dodecatoms, and that as hitherto obtained in the laboratory, the dodecatom of magnesium is undifferentiated, and that of calcium differentiated in the slightest manner, we obtain the following equations :—

$$\text{Magnesium, } G \ldots \frac{(MgMg)^{12}}{\frac{1}{2}AQ} = \frac{24 \times 60}{\frac{1}{2} \times 1620} = 1{\cdot}76 \text{ Exp. } 1{\cdot}75.$$

$$\text{Calcium, } G \ldots \frac{Ca(CaCa)^{12}Ca}{AQ} = \frac{26 \times 100}{1620} = 1{\cdot}59 \text{ Exp. } 1{\cdot}5 \ldots 1{\cdot}6.$$

Their relations to oxygen, also, in their dedoubled state, as compared with their original state, is very interesting. Thus, taking for them in their original state any strange names (since in that state they are not to be expected in nature), as, for instance, for that with single metallic poles the name Sodhium, and for that with double metallic poles Kalhium, and using, as we have done already, the spiritus asper (the h of the Greek alphabet) in the literal symbols as equivalent to the same letter which we have introduced into the familiar names, we obtain—

Dioxide of Sodhium, $O\overset{ʽ}{N}aO$ or $\overset{ʽ}{N}aO_2 = 2MgO$, Monoxide of Magnesium.

Dioxide of Kalhium, $O\overset{ʽ}{K}O$ or $\overset{ʽ}{K}O_2 = 2CaO$, Monoxide of Calcium.

Thus our theory, while it gives us very early in the Plutonic abyss magnesium and calcium, gives them as protoxides, that is, as they occur in nature. And this we hold to be no slender verification of our views, since silica and carbonic acid occur as dioxides, and alumina and iron as sesquioxides, that is, as structures analogous to those in their nascent state, from which magnesia and lime have been here obtained by dedoubling.

And now our theory awakes a most interesting suggestion with respect to calcium. Thus, as now obtained (by the dedoublement of potashium), it is a bi-polar metal, with a non-metallic equatorial region. Its molecular structure, therefore, morphologically considered, is by no means perfect. But its atomic weight is 100. It therefore consists of the material of 20 atoms of hydrogen. Now, 20 is precisely the number of atoms of hydrogen which is required to construct a most perfect icosahedral metallic molecule (see Pl. I. fig. v. H_{20}). Under the sustained operation, therefore, of the law of symmetry and sphericity, our theory leads us to infer that the atoms of calcium will undergo a secular perfectionment, so that at any epoch there may exist in nature two varieties of calcium, whose properties will be by no means the same in every respect. Moreover, since they are so dissimilar, they will tend to unite when they meet, and thus there will result a third variety of calcium, of double the atomic weight, and a much more powerful agent than either of the others. These inferences it is for chemists to inquire into, when they shall think it worth their while.

But an inference that is more interesting than any of these must not be omitted here, for, from these views, it follows that if nascent hydrogen could be condensed into its culmination molecules, that is, into icosatoms, and to these molecules a solidarity, which should prove to be invincible in the laboratory, could be imparted, then the condensed hydrogen would constitute calcium. And here it might be shown that such conditions as might be expected to produce such solidarity, exist in organised, especially in animal structures. With these, however, we have nothing to do at the present stage of our progress.

But this is the place to call to mind that the poles of the median atom of oxygen in the sodhium and potashium forms may be packed by baric and barytic elements, as well as by common elements; and now let us ask what shall we obtain by dedoubling in that case? And here we may confine our attention to potashium, partly because, in consequence of the great length of its axis, its dedoubling may be depended upon, and partly because the atomic weights of baric and barytic sodhium, and then halves resulting from dedoubling, are in such simple ratios with one another and with common sodium, that it does not appear how they could be experimentally distinguished from one or more atoms of the same element.

Baric potashium, then, when dedoubled, must give a metallic element, which must be analogous to calcium in its properties, and whose atomic weight must be—

$$\frac{100 + 100 + 40 + 100 + 100}{2} = \frac{440}{2} = 220, \textit{ i.e. } 44 \text{ when } H = 1.$$

It therefore represents strontium.

Similarly barytic potashium must give an analogous element, whose atomic weight must be—

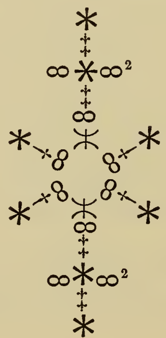
$$\frac{160 + 160 + 40 + 160 + 160}{2} = \frac{680}{2} = 340, \textit{ i.e. } 68 \text{ when } H = 1 .$$

It therefore represents barium.

Moreover, under the law of redintegration, the atoms of both of these metals, like those of magnesium and calcium, will tend to go in couples, so that they also will seem to have double their true atomic weights, and will have only one calorific focus for a couple of atoms. They will also be given to nature as protoxides. And thus, like the other members of the group, we may expect them in union with sulphuric, or sulphic, or carbonic, or other acid.

Magnesia in union with sulphic acid and water, when the quantity of aqueous matter which it tends spontaneously to include in its structure, when crystallised below freezing is present, constitutes a very beautiful and typical molecule. It is most shortly written by chemists $Mg_2SO_4.12H_2O$, where S represents a tetratom of S according to our views, and O two atoms of oxygen. The formula, therefore, becomes to us, $Mg_2S_4O_8.24HO$. Now, separating this chaos into those combinations which are known to tend to form in nature when such elements meet together in such numbers, that is, separating them into magnesia MgO, glacial sulphic acid $SO^3.2HO$, and water of crystallisation, we obtain immediately a finely differentiated dodecatom, the body consisting of $(HOaq)^{10}$, the poles constituted by two atoms of magnesia, each surmounted by an atom of glacial acid. Adopting the astronomical symbol of the last sign of the zodiac to stand for an atom of magnesium, we may thus give a figurate formula of this beautiful structure, which may show something of it to the eye.

Epsom Salt (crystallised below zero),



$Mg_2SO_4.7H_2O. + 5H_2O$ Auct.

But this is the element of Epsom salt when in solution. Its form, it will be seen, is eminently prolate. When, therefore, the aqueous mantle by which it may render itself spherical in solution evaporates, these elements must place themselves as radii in an isometrical molecule. And what must be the structure of that molecule? To this it is to be answered, that both poles are atoms of aq; the molecule, therefore, must be aquaform, that is, it must consist of 36 parts, each similar to the one here figured, with the omission of the 10aq on the body. Now, in that case, allowing its volume to be that of the molecule of ice (= 16AQ) we obtain the following equations of sp. gr.—

$$\text{Epsom Salt, G}\ldots\frac{(Mg_2SO_4.7H_2O)^{36}}{\text{ICE.}} = 1\cdot708 \text{ Exp. } 1\cdot7\ldots1\cdot8.$$

Here then, besides obtaining the specific gravity of this salt *a priori*, we have a verification of the structure which we have assigned to the particle of water (see p. 23); as may also be obtained by constructing the molecule of gypsum, sal-ammoniac, &c.

An inspection of our figurate diagram serves also to explain the well-known relations of this salt to aqueous matter under variations of temperature. Thus it has been found, that when crystallised at several degrees below the freezing point, instead of 14, as usual, it contains 24 atoms of aqueous matter. In that case plainly the body of the common salt is expanded by the incidence of an atom of aq on each of its ten atoms of HO. In this state, as the most perfect, it is represented in the diagram. When, on the other hand, the solution is concentrated, and crystallisation takes place when the solution is warm, the crystals contain only 12 atoms of aqueous matter, that is, the two atoms of aq on the two poles are omitted as those on the body are, except at a very low temperature. And when sufficient heat is applied, it is found that all the water may be driven off except two atoms, that is, the aqueous body consisting of HO^{10} is dispersed, and only the two atoms of aq, which form the nuclei of the two atoms of sulphic acid, and which are necessary to its existence, remain.

The same rationale applies to other sulphates, &c. And surely it will not be denied by any one who has followed what has now been advanced, that our molecular morphology gives an insight into such matters which it is delightful to possess. But the chemist, it appears, has no toleration for it. Well, at any rate, let us proceed. There is a time to come.

Another remark, however, respecting our atom of calcium may here be made. Suppose it does not attain to an internally symmetrical structure, by being transformed into the isometrical icosahedron H^{20}, Pl. I. fig. v., it may yet become internally symmetrical as a bipolar metal, by the transformation of its polar atom of ☋ = 5Ꜧ into an atom of O, also = 5Ꜧ. Now this is often to be expected in the secular course of nature, and in this case the wholly metallic nature of the atom of calcium will, under the law of differentiation, tend to effect it. And now, suppose this transformation of ☋ into O to have been effected, what have we obtained? Plainly, we have obtained an atom of magnesium, in union with one of oxygen.

The Atom of Calcium...Ca = MgO...An Atom of Magnesia.

And thus our theory explains why magnesia is so generally associated with lime, and why there should be in the world so many dolomite beds and mountains.

Sodium, Potassium, Rubidium, Cæsium.—In order to the genesis of magnesia and lime in the way which has been supposed, it is necessary that the dioxides of what I have called sodhium and potashium, should exist in single elements, and not in the molecular state. When they exist in this latter state (and into this state they must hurry as soon as the temperature permits), quite another issue must result. In this state there will no longer be a prevailing tendency to dedoublement, because each element of dioxide being in the position of a radius in an isometrical molecule, the law of sphericity has no fault to find with it.

But if the internal structure of the element of dioxide be anyhow dissymmetrical, it will tend secularly to become symmetrical. Now, on its genesis there is disymmetry in every atom of  (Pl. II. fig. I.), which, for the sake of reference, we may call by the strange name of Lithhium. Thus, an atom of  consists of five bitetrads united by a terminal edge of each as the common axis of all. Consequently, at one end of that axis, in the centre of the five-fid pole, there are twice five units in a group; while at the other end, in the centre of the lens-shaped pole, there are only five. A group of five units, therefore, in the five-fid pole does not enter into the symmetry, and is supernumerary. It is also identical to the second group of five units immediately subjacent. It will, therefore, be repelled by the latter, and tend to be rejected from the structure. But five units are precisely the material of an atom of hydrogen. In being repelled, therefore, and rejected, they will be individualised as an atom of hydrogen. We thus obtain the secular equation—

Lithhium,  =  Hydride of Lithium.

Now, both poles of the atoms equally of sodhium and potasshium are constituted by atoms of . Both poles, therefore, will tend to give off an atom of hydrogen each, and to be transformed into . But both the sodhium and potashium considered at present exist in the molecular state. Now, the conditions of molecular action at the circumference and at the centre of a molecule must be very different. This development, therefore, of hydrogen will not take place simultaneously at both regions; but, on the contrary, it is to be expected that an atom of hydrogen will be given out during one epoch in the peripherad pole, and during another epoch in the centrad pole. Taking, then, for figurate illustration the molecule of dioxide of sodhium as the simpler of the two, and supposing that it is the peripheral pole which is first symmetrised by the emission of hydrogen, we obtain as its diagram—

Hydrate of Soda,

$(NaO.HO)^{12}$.

Now, here we have all over the surface of the molecule, and on each of the twelve constituent elements (of which only the half are seen in the diagram), an atom of

 = HO ;

and between this peripheral moisture and the centre we have in each of the twelve constituents—

 = NaO ;

for the atomic weight of the metallic element now is $35 + 40 + 40 = 115$, *i.e.*, 23 when H = 1. Its atomic weight, therefore, is that of sodium.

In the same way, in the case of the analogous metal with double lithic poles, its atomic weight is now $35 + 40 + 40 + 40 + 40 = 195$, *i.e.*, 39 when H = 1. Its atomic weight is, therefore, that of potassium. And both may be permanent in nature, for each is dissymmetrical in opposite sides of its equator, and, therefore, cannot dedouble. Also, both, according to this theory of their genesis, are given to nature in the first instance as hydrates. Moreover, as to the pure metals, taking them in differentiated dodecatoms, as is most usual, and allowing one normal volume to that with single metallic poles, and two normal volumes to that with double metallic poles, we obtain the following equations of specific gravities—

$$\text{Sodium, } G\ldots = \frac{(Na)^{1+12+1}}{AQ} = \frac{14 \times 115}{1620} = \cdot 99 \text{ Exp. } \cdot 97 .$$

$$\text{Potassium, } G\ldots = \frac{(K)^{1+12+1}}{2AQ} = \frac{14 \times 195}{2 \times 1620} = \cdot 84 \text{ Exp. } \cdot 86 .$$

Here, then, have we not such a theory of these two so highly analogous metals as satisfies all that we know of them? It is, indeed, true that they do not occur in nature as hydrates, which is the condition of their genesis according to the preceding theory; but this, as we shall soon see, arises simply from the tenderness of (the oxyhydric acid) HO, and its liability under the least pressure to lapse into aq, as, for instance, by the incidence upon it of carbonic dioxide, chlorine, nitric acid, &c. But of these things hereafter. Meantime, may I not ask whether anything more satisfactory in a scientific point of view could be desired as to the relations between sodium and potassium when compared together, and both when compared with magnesium and calcium? How many geological phenomena which, on the popular views, seem wholly unaccountable and anomalous, explain themselves most felicitously if we admit this process of doubling and dedoubling as the mode by which the one is transformed into the other, so that each, by the use of the other, can always make its appearance in nature when it is needed! And then as to the protoxides and hydrates, which our theory of the development of these elements necessitates, and which nature either presents to us, or ever tends to revert to in the laboratory, what more strange if this be all imagination! The precise atomic weights, too, which our theory cannot avoid, but which, as it happens, are precisely those which the balance has determined! But let us proceed.

And what now, let us ask, as to baric and barytic sodium and potassium; or rather, let us say, baric and barytic potassium only; for in reference to the atomic weights of the sodiums the same ambiguities exist as have been already referred to, rendering experimental verification ambiguous also. We have to remark, then, that our theory having led us to strontium and barium as elements resulting from the dedoubling of baric and barytic potassium, or full weighted potassium leads us also to expect analogous elements corresponding to the entire structures when these have been rendered dissymmetrical on opposite sides of their equators, so that they cannot partition or dedouble.

But here an interesting fact which attaches to our theory requires to be kept in mind, and it is this: From the five-fid pole of baric and barytic lithhium we are not to expect an atom of baric hydrogen and of baric hylagen to be given out, as we have had an atom of common hydrogen from the pole of an atom of common lithhium. The baric and barytic forms contain disposable units sufficient in number to be developed and given off as elements of the pentagonal order of forms, that is, as forms of the same order as lithhium itself. This, therefore, they will do, because such development is more symmetrical and simple than if the disposable units had to shape themselves into the form of hydrogen, which, whether common or baric, is always trigonal. In the dissymmetrical pole of the atom of baric lithhium there are, in fact, fifteen disposable units, and in that of the atom of barytic lithhium there are twenty. Now these, when given off symmetrically in a form of the pentagonal order, constitute our two borons (monatomic),—the one with five, the other with ten units in the equator, the analogues in the pentagonal order of forms of hydrogen and hylagen in the trigonal order of forms (see Pl. I. fig IV. B, for the heavier sort of boron).

Instead of HO (oxyhydric) elements, then, according to our theory these baric and barytic alkaline elements, when undergoing reduction, will give out BO (boric) elements.

But here it will occur as an objection to this deduction, that such borates do not present themselves in nature in this connection,—nay, that all borates are very scarce. Now, this is true; but here, as in all other cases, our molecular morphology emancipates itself from the objection by appealing to the analogy of nature, and becomes a beautiful illustration of it. Hydrates of the common alkalies are not found in nature in greater quantities than borates. The atoms of HO, as has been shown, when given in this connection, lapse into atoms of aq, thus going to increase the aqueous element on which the mobility and life of molecular nature mainly depend. In the development of the baric and barytic alkalies, the atoms of BO cannot, like those of HO, change their form; but they will unite, one in each pole of an atom of oxygen as the coupling joint. And what do they then give to nature? Using as its symbol a skeleton-faced cypher, which somewhat resembles a section of the atom of boron along the axis, and may remind us of its lightness, we thus obtain—

Sesquioxide of Boron, 80808 = OBOBO = B_2O_3.

Now, when the structure of this combination is considered, it will be seen that there is no chance of its undergoing decomposition according to the mode of its construction. There is no chance of its being resolvable in the laboratory into OB + O + BO. The poles of the medial atom of O are perfect moulds for those of the atoms of B which have plunged into them, and doubtless BOB will thereafter be inseparably welded together, especially since, when thus existing as one form, they constitute an exquisite icosahedron, the most perfectly spherical of molecules. If decomposition can be effected in the laboratory at all, it will be merely separation of the terminal atoms of oxygen, which render the axis of the combination too long. Thus, as the equation of decomposition, we shall have

80808 = 8 + 080 + 8

Now, the atomic weight of the undecomposable icosahedron, when its poles are fully reduced borons, is 15 + 40 + 15 = 70, *i.e.*, 14 when H = 1. Also, from its exquisite sphericity, it must be a very reposing or inactive element. And it occurs in nature in combination with two atoms of oxygen. These facts indicate the equation—

$$\text{Sesquioxide of Boron} \ldots \text{OBOBO} = \text{OSiO} = \text{SiO}_2 \ldots \text{Silica.}$$

Thus, according to our theory, while the hydrating matter developed during the genesis of the common alkalies goes to increase the aqueous element on which the mobility and life of the earth's surface so much depend, the boric matter developed during the genesis of the baric and barytic alkalies goes to increase the siliceous element on which the stability and security of the earth's surface as a theatre for life so much depend.

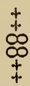
But what, let us now ask, must be the atomic weight of our baric potassium, when, by the emission of matter more or less, one of its poles has been rendered dissimilar to the other, and the whole dissymmetrical, so that it cannot dedouble into two atoms of strontium, as it must tend otherwise to do? It will be found on inspection, that all the matter it can part with, provided it leave five units for a central group to the five-fid pole, is one atom of light boron, its atomic weight 15, *i.e.*, 3 when H = 1. Now, we found that the full atomic weight of baric potashium (= to 2Sr.) was 440, that is, 88 when H = 1. When diminished by the departure of the atom of light boron, that is, by 3 in the hydrogen scale, its atomic weight will therefore be 85 on the same scale. Now, this is within a decimal of the experimentally determined atomic weight of rubidium.

Similarly, it may be shown that barytic potashium, in becoming dissymmetrical on opposite sides of its equator, so that it cannot partition into barium, must give off an atom of full-weighted boron, its atomic weight 20, *i.e.*, 4 when H = 1. Since then its original atomic weight was 680, *i.e.*, 136 when H = 1; it will now, in its permanent non-partitioning state, be 136 – 4, that is, 132. Now, this is within an unit of the experimentally estimated atomic weight of cæsium, which is usually given at 133.

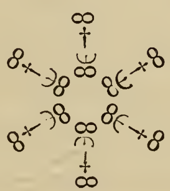
According to our theory, then, these recently discovered alkaline metals, rubidium and cæsium, are in reference to potassium what strontium and barium are in reference to calcium. And I do not see that a more scientific conception of their place in nature can be desired, or a genesis that could explain better both themselves and their circumstances.

Lithium.—In what has preceded, it has been supposed that single atoms of oxygen, as fast as they were formed in the seething abyss, were packed with the bitetrads which were swarming around, and thus there resulted a series of alkaline earths and alkalies of which magnesium and calcium, sodium and potassium, may be regarded as the *terrestrial* types.

The next step is, when, previously to being thus packed, the single atoms of oxygen had succeeded in coupling, after which the external poles were packed as formerly. This we have already found when considering the development of sulphous acid (p. 35), and the same we now find when considering the development of an alkali which may indeed be considered as the ultimate form of sulphous acid when it is prevented from doubling.

Sulphous Acid,  transformable into  Lithic Alkali.

In reference to this new structure, there can be no new elements obtained by dedoubling, for the whole merely consists of two identical structures in apposition, and each by itself more readily than both together will form into dodecatoms. But whether united or separate, their naked metallic poles will forthwith be capped by oxygen. And then, as formerly, an atom of hydrogen will be given out from the centre of the five-fid pole of the atoms of lithhium, and thus, as before, we shall have as the figurate formula—

Hydrate of Lithia,  $(LiO.HO)^{12}$.

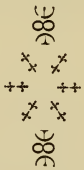
By the egress of the atom of H, the atomic weight of the metallic element is lowered from ♅^{5} = ϖ = 40 to ω = 40 − 5 = 35, that is, 7 when H = 1. It, therefore, in atomic weight represents lithium. Moreover, as to specific gravity, assuming as usual the differentiated dodecatom and that it is so small that it occupies half a normal or aqueous volume, we obtain the equation—

$$\text{Lithium, G...}\frac{(L)^{1+12+1}}{\frac{1}{2}AQ} = \frac{14 \times 35}{\frac{1}{2} \times 1620} = \cdot 60. \text{ Exp. } \cdot 59.$$

Further, it is worthy of remark, that as the single atom of lithium is dissymetrical and heteropolar, this alkali, in the purely metallic state, can only exist as a dodecatom either isometrical or differentiated. Its atomic weight, therefore, must be no less than from 84 to 98 on the hydrogen scale, intermediate between that of rubidium and cæsium, and not far from that of lead. Hence we are enabled to explain the remarkable solvent power of lithium, as compared with sodium and potassium.

And thus the entire series of the fixed alkalies presents itself to us as a system of extreme simplicity. Sodium is an undecomposable suboxide of lithium. Potassium is the same with the lithic elements on its poles doubled. Potassium may be called double-flowering sodium. All the others are their baric or barytic isomorphs, as has been shown.

With regard to thallium, it appears to owe its alkaline analogies to its possession of sodium poles, the body being the sulphic icosatom—

Thallium,  $Na\overset{20}{S}Na = Tl$.

This gives the atomic weight on the hydrogen scale, 23 + 160 + 23 = 206; or if both the atoms of lithium, in the sodiums, be reduced 22 + 160 + 22 = 204, the last being the atomic weight agreed on by experiment. This theory explains, also, why this metal is found among sulphides. But to proceed.

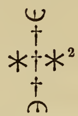
Ammonia.—Anything like a scientific or continuous transition from the fixed alkalies to the volatile has hitherto been an impossibility in science. Between Na and K on the one hand, and NH_3 on the other, there seems absolutely no agreement at all, and yet it is certain that all the three act in a manner which is highly analogous. Our molecular morphology solves this mystery, showing, as it does, that the volatile alkalies are merely the hydrides of that same element of which the fixed alkalies are oxides.

But the conditions of the genesis of the two sorts of alkali, as indeed their functioning in nature, are widely different; and to find a primal or primæval genesis of ammonia, we must leave for a time the Plutonic abyss and reascend into the region where we first found the aqueous element.

When bent on the genesis of that element, in a region where hydrogen alone was to be found, we stopped when we had obtained the hexatom of hydrogen (see Pl. I. fig. x. H^6). But it is needful now to consider that, if in a region where all the hydrogen is disposed in hexatoms, a single atom of hydrogen be anyhow introduced or disengaged, then it is to be expected that on each of the five points for union, in the latter, a hexatom of hydrogen will perch. If the entire medium of hydrogen had been revolved into hexatoms, we have seen that these would group into hexatoms again, and that only aqueous matter would result. But if, along with hexatoms of hydrogen there be, in the medium, single atoms of hydrogen also, then, just as hexatoms do, these single atoms will gather five hexatoms around them. Now, in this case, we must obtain other products. And first, we are to expect that in order to the differentiation and stability of the combination, the five atoms of H, in the hexatom on the poles of the nuclear atom of H, which place themselves around the central atom, will do so by an equatorial instead of a polar angle. We thus obtain a beautiful open or aërial molecule of hydrogen, consisting of five times six atoms around one in the centre, that is, thirty-one in all. Of this a figurate diagram, omitting one of the three equatorial hexatoms, is given in Pl. II. fig. VII. H_{31}. Now, as was supposed when giving the genesis of the aqueous element (see p. 17), let this elemental air-plant fructify by the incidence of single units of matter supposed to be diffused in the ambient on all the points of the equators of the atoms of hydrogen, which are free to receive them. This, it has been shown, the law of sphericity will tend to effect. And from this it will result that the $3H_6$, which constitute the equatorial arms of this combination, will be secularly transformed into—

$$3H\underset{\circ}{H}_5 = 3aq\,.$$

But with regard to the 5H which surround the sixth atom of H in the polar hexatoms of H_{31}, since one of their equatorial angles is engaged already (being the point by which they are held in the combination), they can take on from the ambient only two instead of three units each. Instead of being converted into normal hylagens, they can only give rise to hylagens which want an unit in one of their equatorial angles, the atomic weight of each being seven instead of eight. This new element, then, we may represent by our symbol for hylagen inverted, thus, $\mathring{H}$. Now, there are five of them on each pole of H_{31} in that condition; and that condition is such that it forbids their separating from each other, for each is dissymmetrical and incapable of separate existence. Nay, their dissymmetry requires that, at the first possible moment, they shall arrange themselves in such a group that each may supply the equatorial defect of the others. Now, this will be effected when they all bring their defective equatorial angles to the centre of the combination, thus forming in that centre a circle of five units. But the form at which we thus arrive, is precisely that with which we have been familiar since we began the investigation of the alkalies. It is precisely an atom of lithium! And the axial part of the structure, resulting from the synthesis which we have now followed, that is, from the aërial growth of hydrogen, in hexatoms around a single atom, in the celestial spaces, consists of two atoms of lithium as poles united by an axis, consisting of three atoms of hydrogen (see Pl. II. fig. VIII. ∋H^3∈). And the whole structure is taken into account when the middle atom of hydrogen in the axis is buttressed by an atom of aq on each of its three sides.

Terhydrated Ammonia, .  $AzH_3.3HO$.

Suppose now that this structure is shivered to pieces by electricity or otherwise, what, let us ask, shall we obtain as products of the decomposition? That we shall obtain three atoms of moisture and three atoms of hydrogen, is obvious. But what as to the polar elements? I have said that in structure they are identical with lithium. But their mode of genesis is very different. Their genesis is aërial, nay ætherial, and they are in no degree residua. Lithium, on the other hand, has not only an abyssal origin, but before it has attained to a true individuality and undecomposability, it has given off an atom of hydrogen. Now, it appears that hydrogen when given off in that way carries along with it the wings, the æther, or, more generally, the aptitude, of the structure which it leaves for assuming the æriform state except at high temperatures. But with regard to our lithic structures here considered, everything leads us to infer that when they couple symmetrically, as—

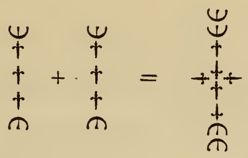
 (See Pl. II. fig. IX.)

they will be eminently suited for the æriform state. Now, of such an æriform the atomic weight is $2 \times 35 = 70$, *i.e.*, 14 when $H = 1$. It is also eminently spherical. It will therefore be eminent for its repose or inactivity in the laboratory, while yet it consists of two halves, each of which cannot but be active in the highest degree if existing singly. All these features mark this new æriform as azote. And thus neglecting the moisture, what we obtain from the decomposition of our ærial alkali are, three atoms of hydrogen and one of azote. Our alkali, therefore, represents ammonia.

Is it asked why I retain the term azote, which has been deemed worthy of a remonstrance against its use by a highly accomplished adept in chemistry? I answer that that term is happily expressive of its repose and inactivity. It also invites us to name its half, which cannot but be intensely active, "Zote;" and this term admits of changes corresponding to the various ways in which these elements may possibly combine with one another, viz.:—

Zote. Azote. Antizote. Bizote.

We shall find that all of these occur in nature, and more especially the last. Thus, bearing nearly the same relations as sodium and potassium, we may have—

Ammonia  Biammonia.

Sodium-like. Potassium-like.

And here let us remark that the single atom of ammonia, unless the middle atom of hydrogen assume the coronal form, or in the trigonal form, be buttressed by three atoms of water or of carbon, or something else, cannot be permanent. It must undergo a most remarkable transformation, analogous to that of HO, when it lapses into aq, but much finer—a transformation which explains at once the eminence of ammonia in the economy of nature, and the seemingly anomalous modes in which it functions in the laboratory.

Thus the five atoms of [illegible], which at present constitute the terminals of the axis of the atom of ammonia, have, as they exist at present, their axes standing obliquely to the geometrical axis of the structure. They will, therefore, under the law of symmetry, tend to place themselves parallel to it. But this implies the opening up of the closed poles of the atoms of zote, which are in contact with the atoms of hydrogen of the axis, so that the atoms of hydrogen might be received within their poles if there were any force which tended to press the opened zotes towards the centre of the structure, and so to shorten the axis. Now, the law of sphericity implies such a force, for the axis of the structure, as it stands, is much too long for the equatorial diameter. The consequence must be the introduction of the two extreme atoms of hydrogen into the group of the five atoms of [illegible], and the genesis, along with them, of two aquaform elements, which will remain bolted together by the medial atom of hydrogen, the resulting form being identical with that of two atoms of aq united by their poles (see Pl. II. fig. x. am). Hence the ammoniacal, like the aqueous element, is, in our theory, eminently dimorphous, and its functioning in the one form must be not a little different from what it is in the other.

Thus, when it exists with zotic poles (Pl. II. fig. VIII.), it will behave like another alkaline metal. But when it exists in its aquaform (Pl. II. fig. x.), both its poles being re-entrant and negative, it cannot unite on the same axis with anything but by the intervention of an atom of hydrogen, or possibly of sulph. Now, in this form it exists very often, and hence the conception of—

Ammonium,  AzH_4

a structure which, when thus composed, is not defective in a morphological point of view, but which the law of redintegration appears to forbid, causing it to lapse into ammonia with discharge of hydrogen, and which, at any rate, is not the ammonium of chemistry.

That the atom of ammonia possesses, sometimes at least, the aquaform, is well shown by the hydrochlorate, its characteristic salt. Thus, to obtain the specific gravity found by the balance, it is necessary to make the following construction :—

$$\text{Sal Ammoniac,}\ \frac{(\text{ClHam})^{36}}{4\text{AQ}} = \frac{36(180+5+85)}{4 \times 1620} = 1{\cdot}5 \text{ Exp. } 1{\cdot}5\,,$$

that is, the molecule must be aquaform.

That the single atom of ammonia is sometimes aquaform is shown also by another natural salt, though the molecule be a dodecatom—

$$\left.\begin{array}{r}\text{The Bicarbonate}\\ \text{of Ammonia,}\end{array}\right\}\ \frac{(\text{OCO,OHamHO,OCO})^{12}}{2\text{AQ}} = (\text{HO.}H_4\text{NO.2}CO_2)^{12} = 1{\cdot}46$$

and others. Indeed, it forms a pleasing study to observe how am, in its aquaform, plays the same part in reference to a heavier class of compounds, that aq does in reference to a lighter class, as is beautifully seen by reference to Fremy's roseo and luteo-cobaltic chlorides, and others.

CHAPTER VII.

THE HALOGENS.

FROM potashium common, baric, and barytic,—that is, from unreduced or crude potassium (see Pl. II. fig. III.), possessing an atomic weight of 200, *i.e.*, 40 when H = 1, and in the same way from the others, symmetrical on both sides of their equators, and protected from the further attacks of oxygen by carrying already an atom of oxygen on each pole—we have obtained by their dedoublement, under the secularly sustained operation of the law of sphericity, the alkaline-earth-metals, calcium, strontium, and barium, and that in the state of protoxides as nature presents them to us. And when the temperature has permitted the as yet entire potashic forms to assume the molecular state we have obtained, by the symmetrising of the axis of either the peripheral, or of the central polar lithic element in all, the true alkalies, namely, potassium, rubidium, and cæsium, and that in the state of hydrated or silicated protoxides.

Chlorine, Bromine, Iodine.—We have now to inquire what elements will be given to nature if the temperature be secularly sustained so as to forbid these alkalies to leave the æriform state, or to resume that state if they have existed in molecules before. This we know may be done with concrete potassium, even in our own laboratories. It may be raised into a green vapour. But when it is in this state, it cannot remain for ever as it is, that is, with one of its poles unlike the other, and heavier by an atom of hydrogen. Its axis must be symmetrised. The heavy dissymmetrical lithic pole must emit an atom of hydrogen as the other had previously done. When, therefore, it has remained long enough in the æriform state, its atomic weight will no longer be 39 but 38 when H = 1. But its axis is as overlong as ever. Is there, then, no way in which it can bring itself more into harmony with the law of sphericity? It cannot do so by partitionment, as it could have done when its atomic weight was 40; for each half would now be dissymmetrical in reference to its own equator, which it was not when the atomic weight was full. But yet, it may plainly bring itself into better keeping with the law of sphericity, if not by shortening its axis, at least by getting rid of the five-fid or metallic expansion of its matter, which extends beyond both the poles of that axis. In a word, the five units, which, by being spread out in a circular manner, render it now a bipolar metal, may be gathered up into an atom of hydrogen on each pole, and thus, from being a bipolar metal, it will become a metalloid. Its poles, instead of being any longer five-fid, will be lens-shaped, and its polar elements isamorphous with B (see Pl. I. fig. IV.) Adopting, then, as has been already proposed, for this lens-shape, as a symbol, a compressed cypher, which somewhat resembles its cross-section parallel to the axis, we obtain for this new metalloid the symbol—

Chlorine,  (see Pl. II. fig. XI. Cl).

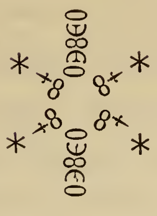
As to its full atomic weight, it is $30 + 40 + 40 + 40 + 30 = 180$, *i.e.*, 36 when $H = 1$. But it will be observed that there are still in the interior of each atom two unreduced lithiums. Each of these, therefore, in order to the symmetrising of its axis, has an atom of H which it must ultimately yield. The ultimate atomic weight of our new element, therefore, shall be $36 - 2 = 34$ when $H = 1$; and it seems not improbable that the dodecatom may be differentiated by having as its poles atoms of this lighter sort, while those of the body of the molecule are full weighted. This would give the mean atomic weight 35·6, which is, as nearly as could be desired, that conventionally adopted for chlorine; and we should have, as the specific gravity of this element when condensed into dodecatoms—

$$\text{Condensed Chlorine, } G = \frac{Cl(\overset{10}{Cl})Cl}{AQ} = \frac{170 + (10 \times 180) + 170}{1620} =$$

$$1{\cdot}32 \text{ Exp. } 1{\cdot}33 .$$

But, doubtless, the normal atomic weight of this element, as long ago determined, is 180, that is, 36 when $H = 1$, which, indeed, the specific gravity of liquid chlorine rather indicates.

This liquid chlorine, however, is not natural to the surface of our planet, and cannot be obtained but by considerable pressure; but about the temperature of freezing water it tends to form, by the aid of moisture, into yellow crystals, the structure of the body of the chlorine dodecatom being the same as that which we have seen in the sulphate of magnesia molecule when crystallised at a low temperature, namely $(aqHO)^{10}$.

Hydrate of Chlorine,  $2(Cl + 10HO)$.

The activity of this new metalloid, like that of the metal from which it is derived, must also be very great, because its departure from the spherical is so great, its axis being so long. So far, therefore, our new element represents chlorine (which, considering such a genesis, we might well write Klorine), and we shall find as we proceed that it does so completely. Meantime, we may remark that, like Kalium, from which it is derived in the state of vapour, it is of a green colour, whence its name.

Rock Salt.—Chlorine is not metallic, at least on its poles, while yet its poles are conformable to those of metals in general. It will, therefore, tend to hurry into union with metals. And more especially as it follows from its shorter axis, that sodium will be surviving as such, in the primæval abyss, during the epoch in which potassium shall have been demetallised into chlorine, it follows that, instead of an alloy of sodium and potassium, as a product of that abyss, we shall have chloride of sodium, or rock salt.

Supposing this salt to exist in isometrical molecules, we obtain as its specific gravity—

$$\text{Rock Salt} \ldots G = \frac{(NaCl)^{12}}{AQ} = \frac{12(115 + 180)}{1620} = 2{\cdot}18 \text{ Exp. } 2 \ldots 2{\cdot}22.$$

Hydrochloric Acid.—But when existing in regions where heavier metals are not to be found, the atom of chlorine, notwithstanding the length of its own axis, must tend to retain in union with it one of the atoms of hydrogen which it has given out, or more generally one atom of hydrogen; for among light elements there is no such strong affinity in nature as that of hydrogen for oxygen, atom for atom. Nor is there any molecular combination in nature which possesses the same interest and importance as the primal HO. Now, an atom of O is the coupling joint, the equatorial element, of an atom of chlorine; and though there is matter in union with that atom of O on both its poles, yet that matter in each pole is similar and equal, and, therefore, both sides balance each other, leaving the atom of O still with its demand for an atom of H, on one pole or the other. The intervening matter, in fact, is no more to the affinity between H and O, than a table with a needle lying on it is to a magnet held beneath that table. Thus do we obtain HCl or ClH, and in the smallest symmetrical combination—

Chlorhydric Acid, HClClH = 2HCl. The least molecule.

And it is an acid; for this is a class of substances of which, though it cannot be said universally that they are salts of hydrogen, yet it may be said universally that if they have a sharp and sour taste, then, at least, one terminal of their axis is a lance-shaped form, such as H or S, as was, indeed, long ago divined by Lemery.

As to the specific gravity of hydrochloric acid in the dense state, it follows that since one pole of the acid is trigonal and the other pentagonal, it may form into two kinds of molecules, the one being the icosatom, and the other the dodecatom. Moreover, in order to the most complete differentiation of the still unstable liquid, we are to expect that it will form into both kinds of molecules in equal numbers. In this way its stability will be helped as far as possible. Now, if this take place, and if we allow (as we shall find that we usually have to do) two normal or aqueous volumes for the larger molecule, the icosatom, and one for the smaller molecule, the dodecatom, we obtain—

$$\text{Condensed Chlorhydric Acid, } G = \frac{(\text{ClH})^{20}}{2\text{AQ}} + \frac{(\text{HCl})^{12}}{\text{AQ}} = 1{\cdot}26 \text{ Exp. } 1{\cdot}27.$$

This acid has, as might be expected, a great demand for water; and it has been remarked that all weaker and all stronger acids may be reduced by boiling to an acid which has the seeming arbitrary and capricious formula of HCl + 16HO, its specific gravity = 1·111. Our molecular morphology shows, however, that there is nothing really arbitrary or capricious in these numbers. Thus we have found that the most stable form of aqueous matter is the dodecatom $(\text{OHaqHO})^{12}$ (see p. 23). Now, when we differentiate this aqueous dodecatom by substituting for the polar elements atoms of simply hydrated chlorhydric acid, we obtain—

$$\text{The most stable Acid, } \frac{\text{aqHCl}\overset{10}{(\text{OHaqHO})}\text{ClHaq}}{2\text{AQ}} = \frac{2(\text{HCl} + 16\text{HO})}{2.\text{AQ}} =$$

$$1{\cdot}111 \text{ Exp. } 1{\cdot}111.$$

Bromine and Iodine.—And now, what as to the other halogens—bromine, its atomic weight 80, and iodine, its estimated atomic weight

127, when H = 1? This question our theory easily answers. Thus it led us to look for a baric and a barytic potassium as well as a common potassium, though in comparatively small quantities, in our planet; and we found rubidium and cæsium precisely answering our anticipation. We have now to make the same remark respecting chlorine. We have to look for a baric and barytic chlorine, and what do we find? Chlorine we have found to be demetallised potassium, that is, potassium when the five units previously so disposed as to render its poles five-fid or metallic, have gathered themselves up into an atom of hydrogen on each pole and gone off. We are, therefore, to expect two metalloids corresponding to rubidium and cæsium, derived from them in the same way. In this case, however, as has already been shown (see p. 54), in order to abolish the flowering five-fid or metallic poles, it is not five units merely that must go off, but five units, each of them a tetradic group, that is, 5 × 4 = 20 units from each pole. Now, this gives the following equations:—

$$\text{Demetallised Rubidium} = 440 - (2 \times 20) = \overset{H=5}{400} = \overset{H=1}{80} = \text{Bromine.}$$
$$\text{Demetallised Cæsium} = 680 - (2 \times 20) = 640 = 128 = \text{Iodine.}$$

As to their specific gravity, bromine appears to have been obtained, like chlorine, in simple dodecatoms, while in the case of iodine some of the molecules appear to have been differentiated in the mass or crystals that have been weighed. Thus—

$$\text{Liquid Bromine,} \quad \frac{Br^{12}}{AQ} = \frac{12 \times 400}{1620} = 2{\cdot}99 \text{ Exp. } 2{\cdot}99.$$

$$\text{Solid Iodine,} \quad \frac{I^{12}}{AQ} = \frac{12 \times 640}{1620} = 4{\cdot}74 \text{ Exp. } 4{\cdot}94?$$

The long axis of the halogen elements, and their consequently great departure from the spherical, invests them with great chemical activity. It also gives rise to a double series of compound forms, in which the ratio of the constituents is the same, namely, a nascent form in which the addition is made on the equator of a single atom of the halogen, and a culmination form in which the former have doubled into dodecatoms more or less differentiated. These have been obtained to the largest extent when the halogen has been combined with oxygen; for though oxygen be non-metallic like chlorine and the other halogens, at least on their poles, yet oxygen and a halogen may be made to unite, and the combination even isolated, at least when something metallic exists in the molecule, such as the atom of H in HO. But the proper metalliser is K, giving in the culmination form $2.KO.ClO_5$ =

$$\text{Chlorate of Potass, G} = \frac{(OKCl\overset{10}{O}ClKO)^{12}}{4AQ} = 2{\cdot}0 \text{ Exp. } 1{\cdot}99.$$

Oxides, &c.—The various oxides begin to form in the usual way as suboxide, sesquioxide, and dioxide, all of which are symmetrical. Thereafter these, as also the pure atom of chlorine, lay hold of five atoms of oxygen to surround their equators and improve their sphericity, and ultimately these, by doubling, give us the series of dodecatoms—

Suboxide, ...	ClOCl	$ClOCl\overset{10}{O}ClOCl$	=	$4.ClO_3$
Sesquioxide, . . .	OClOClO	$OClOClO\overset{10}{O}OClOClO$	=	$4.ClO_4$
Simple element, .	Cl	$Cl\overset{10}{O}Cl$	=	$2.ClO_5$
Dioxide, ...	OClO	$OClO\overset{10}{O}OClO$	=	$2.ClO_7$
Protoxide, ...	ClO	$OCl(Cl\overset{10}{O})ClO$	=	$12.ClO$.

The different halogens, though isomorphous, being dissimilar in structure and weight, may also be made to unite with one another. Thus the first form of differentiated molecule here given may be constructed of chlorine instead of oxygen, and iodine instead of chlorine, giving, when drawn and quartered by the chemist, ICl_3, &c.

The Sea.—Leaving these creations of chemical art, also the chemist to take care of his eyes when dealing with such forced substances, which are ever tending to find their way back into nature, even with explosive violence, it may be now remarked that we are in some measure able to understand the composition of the ocean. It is commonly looked upon merely as a dilute solution of such mixed salts as happen to find their way into it from the solid bed on which it rests. Our theory presents quite another view. Our theory leads us to regard an unit of the ocean as in some sense an organic unity, possessing generally and tending to possess everywhere an exquisite symmetry of structure, and no doubt generally also a self-conservative and restorative power. This we cannot show here, indeed, in detail and convincingly, because that would demand many pages, and not a few elaborate diagrams. But we may show that such a conception belongs to the unity of our molecular philosophy, and thus we can put the reader in the way of understanding it, and of believing it if he is disposed.

The first question comes to be, Why is there such a large quantity of chloride of sodium in the sea, when compared with other saline ingredients, which are much more abundant in its bed? Now, to this it is a most philosophical answer, that chloride of sodium ministers to the life of the world much more than any of the other salts, being indeed indispensable to our own life. It is also a good reason to assign that its presence in sea-water to the extent to which it exists retains the sea in a liquid state, when, but for its presence, the sea must have frozen.

And there are other reasons of the same class, all of which are, as I have said, rightly entitled to the name of good and philosophical, because they lead the mind at once to that which must ever be the highest pursuit in science and the last word in philosophy, namely, the relation of the creation to the Creator. But the aims of the student of molecular science should be to discover, if he can, how such benignant designs have been practically accomplished, and how they are secularly maintained by the ordinary working or weaving of nature. Now, this is what our theory enables us to do with respect to sea salt and the sea generally. We have not, indeed, sought the genesis of sodium and potassium in the aqueous element, but, on the contrary, in a Plutonic abyss, in which there was no reference to water. It will be seen, however, that, granting a vapoury, ultimately an aqueous, medium to have condensed into a globe of sufficient mass, there would be found our Plutonic abyss in its central parts, and that seething medium of bitetrads from which we obtained sodium and potassium as primal elements. And let this remark suffice here, for preventing the conception, on the part of the reader, of any discontinuity, according to our views, between the waters of the ocean and the salts that are in it.

But why have we not potassium as well as sodium salts, in such abundance as would be seemingly natural in the circumstances? That is the question. Now, it is answered by the fact, that the axis of the atom of potassium is much longer than that of sodium. It exists in violation of the law of sphericity to a much greater extent. Hence, during the same epoch in nature, it undergoes demetallisation in much greater quantities; and while sodium is still retaining its metallic state, potassium has been demetallised into chlorine. Now, since these two elements are metallic and metalloidal respectively, and therefore dissimilar, they will enter into union with each other when they meet, and there will result an atom of table-salt. If the sodium existed previously in the state of oxide, that will be no hindrance to this combination; for the potassium, when transformed into chlorine, must be given to nature as chlorhydric acid, of which the atom of H will rush into the atom of O of the oxide of sodium, both lapsing together into aq, and leaving the simple chloride NaCl. Here, in fact, we have a phenomenon which is of very frequent occurrence, especially in organic chemistry, viz., the power which a combination manifests of shortening its axis by the union of H and O, when they meet in the same axis. Lapsing together into aq, they generate a hexagonal form, which is no longer conformable to the positions in the axis where H and O were before, and which, therefore, must be thrown aside.

Thus we shall obtain abundance of chloride of sodium for the ocean.

But to what extent shall it be introduced? We have already seen (see page 26), or, at any rate, by a sufficient number of the relative diagrams, it may be shown that the atoms of the aqueous element tend to go on aggregating in nature until a differentiated dodecatom of AQ is constructed, which I have referred to as a minim rain-drop. Now, in its centre there is a vacant space every way suitable for giving permanent and secure lodging to a saline element. Let us, then, take the smallest portion of chloride of sodium which is symmetrical, and, consequently, capable of existing separate, or out of the molecule state,—that is, let us take a coupled molecule, ClNaNaCl, and let us place such an element in the centre of the composite aqueous particle referred to, and do we not obtain chloride of sodium and water in the very ratios in which they exist in—

$$\text{Sea-Water,} = \begin{array}{c} \overset{3}{AQ}\quad\overset{3}{AQ} \\ AQClNaNaClAQ \\ \underset{3}{AQ}\quad\underset{3}{AQ} \end{array} \qquad \text{Salt per cent., 2·53...Exp. 2·52.}$$

Nay, not only do we by this construction obtain the percentage of nature, but we see why it requires a greater degree of cold to freeze sea-water than to freeze common water. The double molecule of salt forms an axis for the molecule, which keeps it stretched, and assists in excluding from that centre the atom of AQ, which must find its way there before the ice molecule can be formed, and the liquid congeal (see page 27).

It may here be remarked, however, that this marine molecule may be differentiated by a dodecatom of salt on the poles, instead of a particle of AQ. In that case we obtain—

$$\text{Brine,}\quad \begin{array}{c} \overset{3}{AQ}\qquad\overset{3}{AQ} \\ (ClNa)^{12}ClNaNaCl(NaCl)^{12} \\ \underset{3}{AQ}\qquad\underset{3}{AQ} \end{array} \left\{ \begin{array}{l} \text{Water, 100.} \\ \\ \text{Salt,}\quad \text{39.} \end{array} \right. \quad \text{Exp. id.}$$

By the discharge of the salt in the axis, this molecule may also exist, and be partitioned into twelve, each of them symmetrical—

$$\text{Penetrating Brine,}\quad ClNaAQNaCl \left\{ \begin{array}{l} \text{Water, 100.} \\ \\ \text{Salt,}\quad \text{36·4.} \end{array} \right. \quad \text{Exp. id.}$$

At certain temperatures, one kind of brine molecule appears to prevail; at certain temperatures, the other. At any rate, the reader will remark that these are the very limits to which water can be charged with common salt at the surface of our planet.

But what is the structure of an integrant molecule of the ocean?

According to what has been just stated, its original materials are sodium and potassium, along with water, in minim rain-drops.

We have also seen how, instead of potassium, if it do not dedouble, we are to expect chlorine.

But both sodium and potassium, when possessing the structure proper to their genesis, may dedouble—sodium into magnesium, and potassium into calcium. These metals, therefore, we may expect in sea-water.

And, moreover, those metals we have found to be brought into great harmony with the molecular conditions of the surface of the terraqueous globe, when, by the aid of sulphic acid, they have attained to the state of Epsom salts and selenite. Now, in the abyss there could be no want of sulphic acid, for its very first issue is $SOS = SO_2$; which, on the supply of moisture, tends to construct $S\vdots aqS = SO_3HO$. We have also seen that both of these salts tend to form aquaform molecules (see pp. 31, 41). Such sulphic molecules, therefore, in an aqueous medium such as the ocean, would be in perfect harmony with their environments. The law of assimilation bearing on them from the aqueous particles of the surrounding medium, vast though its quantity be, would have no tendency to change them. For aught that appears, both might be secularly stable, if encased in lime or magnesia.

Let these sulphic molecules then be so encased, then surrounded by composite molecules, each of them a differentiated dodecatom, consisting of fourteen of the primary differentiated dodecatoms, in the centre of each of which the chloride of sodium nestles, and let each of them have also an atom of chloride of magnesium on each pole, and let the whole aqueous medium consist of such molecules, in equal numbers; and both the structure and its differentiation of that medium are very perfect, and it may be expected to be very stable.

At any rate, an integrant molecule of it—which, however, without diagrams, is perhaps wholly obscure—gives the very percentages which are found in analysis in ocean water.

	Water.	Theory.	Experiment.	
	$14AQ^{14}$, ...	968·5 . . .	968·5	Water.
	$14(NaCl)^2$, ...	25·2 . . .	24·6	Table Salt.
36	$2(MgCl)^2$, ...	2·9 . . .	2·6	Bitter Salt.
	$1(MgOS\vdots aqS)^2$, ...	2·1 . . .	2·1	Epsom Salt.
	$1CaOS\vdots aqSaq$, ...	1·3 . . .	1·1	Hard-Water Salt.

CHAPTER VIII.

CARBON, HYDRO-CARBONS, OXYCARBONS.

By the secular demetallisation of the polar elements in the potassium-forms, then, we obtain the halogens. We have now to inquire what we obtain as the result of the same process in the sodium-forms, along with which we may take the lithium-forms, since they differ from the sodium-forms only in this, that the oxygen-form in the latter is coupled instead of single, so that the structure is always ready to open into two—

Lithhia,  = 2

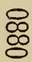
And as, in reference to potassium, in order to obtain its reduction to chlorine, we assumed the existence in the first instance of the peroxide, let us now do the same with the sodhic and lithhic bodies.

In this way, by the emission of two atoms of hydrogen from each pole, the first to symmetrise the axis of the polar atom of lithhium, and the second to demetallise it (both hydrogens lapsing, along with the two atoms of oxygen on each pole, into aq), we obtain the following equations:—

giving by union,

Peroxide of Sodhium,  =  + 4 aq

=  + 8 aq.

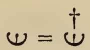
Peroxide of Lithhium,  =  + 4 aq

Now, of these reduced forms, the lower, having two atoms of oxygen for its medial body, must tend to open; and it is to be observed that the latter when opened is the morphological complement of the other, so that if it open and receive the upper, the latter will fit into it as a mould, and we shall obtain a structure of great perfection, not without analogy to a halogen, as in the diagram on the right. Its form, like that of a halogen, is axial or cylindrical, and its poles are identical with those of the halogen. It differs only in embodying no metallic element. It is, consequently, less fully differentiated, and must be less coherent or stable, and, therefore, may possibly in some cases be decomposable. (For its determination see p. 88, *et seq.*)

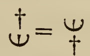
But what are these lens-shaped polar elements? They are obviously isomorphous with boron, and we have already seen them in the poles of the atoms of chlorine. Here, however, we find them not only on the poles, but in the interior of our quasi-halogen also.

Marsh Gas.—Neglecting for the present the light, the baric, and the barytic isomorphs of this lens-form, and attending to that species only which is obtained from the reduction and demetallisation of lithhium, we shall ascertain most easily what it represents in the laboratory, by following out the symmetrising and demetallisation of a single atom of lithhium taken by itself.

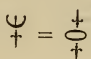
First, then, as has been already shown, we obtain the equation—

Lithhium,  Hydride of Lithium.

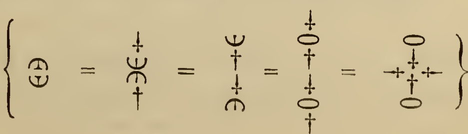
But the atom of hydrogen thus emitted, in order to symmetrise the axis, stands in the centre of a metallic region. Being itself metallic, it will therefore be repelled from this region, and betake itself to the other—the lens-shaped or metalloidal pole; we shall thus obtain—

Nascent Hydride of Lithium,  Mature Hydride of Lithium.

And now the atom of lithium may at once symmetrise both itself and the whole structure, by gathering up the five units which constitute its five-fid pole into another atom of hydrogen. We thus obtain—

 (See Pl. II. fig. XII. HCH).

But of this symmetrical combination the axis is too long. Under the law of sphericity, therefore, such structures will tend to double. Now, this they can do, and by so doing produce an exquisitely spherical and finely differentiated molecule, as we shall presently see. But first, let us remark, that atoms of lithhium, being dissymmetrical and heteropolar, never can exist single. The smallest number which can be isolated is a couple. Let us take a couple, then, and we shall obtain—

The genesis of Marsh Gas,  (Plate II. fig. XIII. CH_4C).

That is, two atoms of this new lens-shaped element, united by a tetratom of hydrogen, as the body of the combination.

Carbon.—What then, let us ask, is this new element? As to its atomic weight it is obviously ◡ − 2H = 5H̥ − 2H = (5 × 8) − 2H = 40 − 10 = 30, *i.e.*, 6 when H = 1. It is, however, so oblate that when atoms of this kind are free to do so, they will tend to go in couples, like oxygen, &c., the atomic weight of which will, of course, be 12 when H = 1. Moreover, this new element has, during its genesis, given off no less than two atoms of hydrogen; carrying, as we have already seen occasion to believe in other cases, an aptitude for the æriform state along with them. We may expect this element, therefore, to be of a peculiarly stable or fixed character.

The Spiral Filament.—And what as to the molecules which it must form? First, it appears that if atom is united to atom by a terminal edge in both cases, and as symmetrically as the system admits of, there results a spiral filament (Plate II. fig. xiv.)

The Diamond.—Secondly, it appears that as soon as twelve atoms have been united, they may spherify into a dodecatom of exquisite solidity (Pl. I. fig. vi.) And what will be the molecule which we may expect to be in volumerical relation with the unit volume of water? Indicating, for convenience, in the meantime, this lens-shaped element by the letter C, we may expect, in consequence of its extreme minuteness, the dodecatom will at once cover itself symmetrically with another layer of atoms, that is, as we have seen, with 20, thus giving an exquisite molecule, at once isometrical and differentiated, and therefore very stable. Now let these small bodies, of such mechanical perfection, form into dodecatoms, as they must—since they belong to the pentagonal system—and we obtain an unit, having the sp. gr. of—

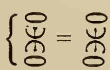
$$\text{Diamond, G}\ldots\ \frac{(C_{32})^{12}}{2AQ} = \frac{12 \times 32 \times 30}{2 \times 1620} = 3{\cdot}55 \ \text{Exp. } 3{\cdot}55.$$

And suppose that at the requisite temperature this molecule is exposed to oxygen gas, so that the icosahedral coating of the dodecatoms should go off in burning, we should then obtain a molecule agreeing completely in sp. gr. with that of the—

$$\text{Unburnt Residuum, G}\ldots\ \frac{(C_{12})^{12}}{AQ} = \frac{12 \times 12 \times 30}{1620} = 2{\cdot}67 \ \text{Exp. } 2{\cdot}67.$$

This new element, then, isomorphous with boron, represents carbon. It is, indeed, true that a majority of chemists at present give the atomic weight of carbon, not as 6, but as 2 × 6 when H = 1. And this the estimating of the atom of oxygen at 2 × 8, instead of 8, necessitates. The farther we proceed, however, we shall see more clearly that the law of symmetry, which ever calls for a couple of atoms in the axis of a molecule, except in the case of the central atom itself, must, as long as it is disregarded, lead chemists to mistake double for single atoms, as also their tendency to go in couples, when forced to do so, as best fulfilling, when thus coupled, the law of sphericity.

The Relation of Chlorine to Cyanogen.—Having thus determined that our second lens-shaped element is carbon, we are now able to understand the analogies of chlorine. Thus it will be seen that in chlorine the polar elements are carbons, and they are grasped, both of them, as we may say, in the talons of lithhiums or zhotes. Omitting, then, the consideration of the concealed atom of oxygen in the middle of the atom of chlorine, which forms the coupling joint of the functioning parts, what we obtain, as these parts, is a couple of carbo-zotic elements, which, if separated from the coupling joint, would give an isomorph of cyanogen.

Chlorine, minus its coupling joint ....  = NC_2 Cyanogen.

Thus does our theory incidentally explain most satisfactorily what has hitherto been deemed a wonder in chemistry, namely, the great similarity in the functioning of chlorine and cyanogen.

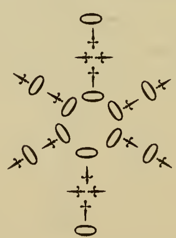
In the giving of carbon to nature, then, every atom is given in connection with two atoms of hydrogen, which are, as it were, its offspring, and it is re-established in all its rights, and exists in admirable harmony with the laws at once of symmetry, sphericity, and stability, when two atoms have become the poles of an aërial body, which consists of a tetratom of hydrogen, that is, when the hydro-carbon has attained to the state of marsh gas. In this state, indeed, it is so perfect, that if undisturbed from without it seems well-nigh unalterable under cosmical law. An atom of carbon consists of ten triangles of forces leaning upon each other between the equator and the poles of the pentagonal bipyramid which they form, so that each set of five roofs in the other; and though it may possibly be developed into a coupled atom of light boron, so that an atom of marsh gas should be transformed into a hydride of boron isomorphous with olefiant gas.

Olefiant Gas,  = C_4H_4,

yet such a transformation would be extreme; and marsh gas presents itself to us not only as one of the most stable of structures, where the heat does not partition it, but as one of the ultimate products of nature.

It is stable, not only in the sense of mechanical perfection, but in respect of the repose which its sphericity and differentiation secures to it, as also because of the fact that between the poles, which are the regions most liable to attack in all molecules, there lies a tetratom of hydrogen. Now, of this structure, the form, as has been shown (p. 16), is so oblate or negative that it warns off oxygen whenever it comes near it. Hence, though the poles of the atom of marsh gas are single and naked atoms of carbon, they are secure against the attacks of cool oxygen. Now we know, in point of fact, that marsh gas can survive the decomposition of all tender molecules, and exist in the midst of all the moisture and the oxygen of the terraqueous globe, both in the crust of the earth and in the atmosphere.

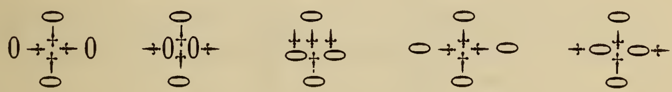
Rock Oils.—It is important to remark how well marsh gas can defend itself against the attacks of oxygen, even when the oxygen is assisted by moisture. That it can do so is implied in its name; nay, it appears that those naphthas and rock oils which now begin to be found in such abundance and to prove so useful, in so far as they are permanent, consist of molecules whose poles are atoms of marsh gas; and on this ground it is that they are protected from the attacks of oxygen and moisture. Thus the most abundant and stable constituent of these natural oils has been found to have the chemical formula of $C_{12}H_{14}$; and, doubling this formula, as is generally necessary with respect to formulæ, which are estimated in reference to a single atom of chlorine, &c., that is, in reference to one pole instead of two, we obtain $C_{24}H_{28}$. Now this immediately bespeaks a differentiated dodecatom in which the body is a double wall of $CH = (C_2H_2)^{10}$, and the poles atoms of marsh gas $= 2(C_2H_4)$. And so with the other members of the series to which this molecule belongs. Their poles are always atoms of marsh gas. As the three hydrogen arms of the terminal atoms of marsh gas in this structure extend beyond the central atoms of carbon, its ultimate or composite molecule may be, and appears to be, that of the trigonal order, namely, the icosatom occupying an ice volume.

Rock Oil,  $2(C_{12}H_{14})$.

The distillate $G = \frac{(\overset{4}{CHC}(\overset{10}{C_2H_2})\overset{4}{CHC})^{20}}{ICE} = \frac{17200}{16 \times 1620} = \cdot 664$ Exp. $\cdot 669$.

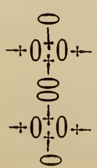
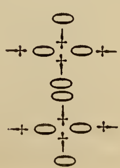
In many cases, however, where there are trigonal poles, plainly the tetrahedral molecule is to be expected. It is only where the whole liquid is somewhat homogeneous that the icosatom can be constructed. With regard to the rock oils in their natural state, doubtless the liquid is differentiated in a very high degree; and it is therefore only what is to be expected that, by effecting distillation at varied temperatures, quite a series of hydrocarbons should be obtained. Their general characteristic, however, as has been stated, if they be permanent in nature, is that their polar elements are atoms of marsh gas, single or doubled.

Essential Oils.—It is only from the inorganic or disorganised regions of nature that marsh gas is to be obtained. Living nature is not so prodigal of her hydrogen as to let a tetratom escape with its three equatorial arms naked. In constructing the marsh gas type, living nature usually gives atoms of CH instead of H only for the three equatorial arms; and hence of this type a great variety of forms, for the atoms of CH may themselves be constructed in three ways, and these may be applied to the axial atom of H in several ways also. Omitting one of the three equatorial carbons, which cannot be introduced in our method of type diagrams, we obtain as tetratoms of hydrogen, fully charged with single atoms of carbon, the following diagrams:—



Now, of all of these the actual forms, though not the diagrams, are very oblate or negative. While, therefore, they will ward off the oxygen which they may happen to meet with, and will thus be permanent in nature, and may be useful in the vegetable tissue in decomposing dioxide of carbon, as has been hinted already, and as will be considered more fully hereafter, they will not be insulable each by itself, any more than a single atom of oxygen or of carbon.

But no reason appears why they may not be insulable in couples on the same axis, and thus coupled attain the æriform state. Now, if we assume that they rise in this coupled state, and that a couple occupies the normal atmospherical volume, that is, the volume of an element of aq or Az or ©, we obtain—

Fragrance,  and  $= \frac{C_{20}H_{16}}{2}$.

The sp. gr. of the vapour, $\frac{C_{10}H_8}{\text{Air.}} = 4{\cdot}7$ Exp. 4·7.

When the vapour condenses, since its equator is trigonal, and extends so far beyond the poles, the molecules resulting must be those of the trigonal series, the first and simplest of which is the tetratom, and the most perfect the icosatom. Now, the tetratom being $4(C_5H_4) = C_{20}H_{16}$, and this is the usual formula for the non-oxygenated essential oils, and allowing a half normal volume to a single tetratom, or a normal volume to a couple of such, we obtain—

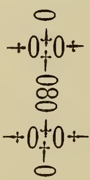
$$\text{Light Essential Oil, } G = \frac{(C_5H_4)}{\frac{1}{2}AQ} = \frac{4(150+20)}{\frac{1}{2}\times 1620} = 84 \text{ Exp. } 85.$$

It is well known, however, that the distiller in obtaining these oils is troubled with a less fragrant, that is, a more stable kind, whose chemical formula is the same, but which is heavy enough to sink in water. Now, the same hydro-carbon element wherein icosatoms must be more stable, and in that case as to the sp. gr. of this.

$$\text{Heavy Essential Oil, } G = \frac{(C_5H_4)^{20}}{2AQ} = \frac{20(150+20)}{2\times 1620} = 1{\cdot}05 \text{ Exp. } 1.+$$

The single element (C^5H^4) is, however, capable of assuming so many forms (figurate formulæ have been given of five) that the isometric molecules which may possibly be constructed of it may be very many.

Camphor.—But here it may occur to the reader that if the single elements are apt for being coupled on the same axis, as we have supposed they are in the case of the ordinary æriform element, are we not to expect them to occur coupled permanently in nature by nature's usual coupling joint—namely, an atom of oxygen? This is plainly to be expected. Now, this gives the composition of

Camphor,  $\frac{C_{20}H_{16}O_2}{2}$.

Supposing it to form into tetratoms like the light essential oils, of which it is the first oxidation (the sub-oxide), its formula of sp. gr. gives

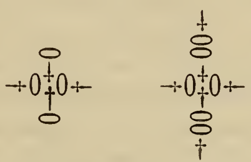
$$\text{Camphor, } G = \frac{(C_{10}H_8O)^4}{AQ} = \frac{4\times 380}{1620} = {\cdot}938 \text{ Exp. } 98.$$

This hydro-carbon element, then, (C_5H_4) we may regard as the characteristic hydro-carbon of the vegetable kindom. It is that molecular structure to which that kingdom mainly owes its fragrance, and I have hinted that it may possibly perform a very important function in the vegetable kingdom—namely, the decomposition of carbonic acid, and the delivering of single atoms of carbon in the free state into the vegetable tissue.

The Hydro-Carbon of the Bile.—And here we may cursorily inquire whether any analogous hydro-carbon is to be found in the animal kingdom. If we are to find it, of course we must look for it in the cells of some region of the animal organism which is analogous to the cells of the parenchyma of the foliage or barks of plants. Now such, I think, are the cells of the hepatic organism, and there, it is well known, that we do, in point of fact, find resins and oily matter highly analogous to those of plants, which indeed, by chemical purification and reduction, may ultimately be rendered fragrant like those of plants.

Do we, then, find in bile any characteristic hydro-carbon analogous to that which we have found in the vegetable organism? To this it is to be immediately answered that we do. In a word, we find the same hydro-carbon, only that in the animal its poles are doubled, or rather CH is added to each, so that the biliary or animal, when compared with the vegetable essence, is what potassium is to sodium, or what acetene is to marsh gas.

The hydro-carbon of Essential Oil,



The hydro-carbon of Bile.

Its chemical formula is C_7H_6, but there is not much chance of its being isolated. In the biliary fluids it seems to exist always as a dodecatom, twelve atoms being studded around an atom of hepatic sugar as the nucleus, the two polar elements at the same time being variously differentiated, especially by such ammoniacal and sulphuric matter, as on its individuation, gives glycocine and taurine.

Dyslysine.—By availing himself, however, both of the decompositions of nature and art, the chemist has succeeded in obtaining the biliary dodecatom, composed wholly of its characteristic hydro-carbons, clothing an atom of saccharine matter as the nucleus, the peripherad atom of hydrogen in the saccharine matter serving also for the centrad atom of hydrogen in the hydrocarbon. Thus—

$$\begin{array}{ll} \text{The saccharine nucleus,} & C_{12}H_{12}O_{12} \\ 12(C_7H_6 - H), \ . & \underline{C_{84}H_{60}} \\ & C_{96}H_{72}O_{12} = 2C_{48}H_{36}O_6 \ldots \text{Dyslysine.} \end{array}$$

Cholesterine.—As long as an atom of glycogenic or saccharine matter, containing in its structure twelve atoms of oxygen, is the nucleus of a molecule of bile, there is no chance of that molecule becoming too stable for undergoing the metamorphoses from hour to hour which animal life implies. But, as might be expected, that atom of sugar is liable to undergo reduction by the departure of atoms of HO. And the study of the salicinic molecules, as well as the law of symmetry, leads us to infer that we might have sometimes, as the ultimate dodecation from sugar,

 $= C_{12}O_4.$

And this structure being so finely differentiated and still protected from the attacks of oxygen, by having its poles charged with this destroyer, cannot but be very stable at all moderate temperatures. Now, if we take this caramelic element as a nucleus instead of an atom of sugar, and clothe it as formerly with our biliary hydro-carbons, differentiating the poles not by such easily transformable forms as the ammoniacal or sulphuric elements, but by the stable forms of marsh gas coupled on each pole and surmounted by an atom of HO, and terminated by one of aq, to bring the whole into harmony with the general moisture of organisation, we obtain a structure which cannot but be comparatively stable, and which may well bear the name of cholesterine. At any rate, its formula is precisely that of that beautiful but often inconvenient biliary solid which forms gall stones in the gall-bladder, and is apt to make its appearance almost anywhere in the animal body, as also sometimes in the vegetable.

Nothing can surpass the beauty of this and of these molecules, even in such figurate formulæ as the student can easily draw for himself with a pencil; and which, indeed, I should like to introduce here, but that I feel ashamed to tax so severely the patience and ingenuity of the printer.

As to the differentiation of the poles in glycocholic and taurocholic acids also, it is easily seen what the material is; but for placing the various elements in the relative positions in which they stand in nature, there is not at present sufficient light.

The Hydro-Carbon of the Alkaloids.—The ultimate hydro-carbon of nature results when the three equatorial atoms of hydrogen in the essential-oil-element have gone off, and there remains only the axial atom of H, charged in each of its five regions by union with an atom of carbon—

 $= C_5H.$

When rendered heteropolar and active by the incidence of an atom of HO, or one of its poles, it enters largely into the more highly carboned products of the vegetable kingdom, such as morphia and the other alkaloids. But in the laboratory it cannot be raised into the æriform state. It merely remains among carbonaceous residua, thus explaining why it is next to impossible to free these residua entirely from hydrogen. It is otherwise unknown to the chemist.

Naphthaline.—But as soon as a second atom of hydrogen is added on either pole, it is capable of the æriform state—not indeed in single atoms, for they are dissymetrical, but in couples—

Napthaline Vapour, . .  $\frac{C_{20}H_8}{2}$

Its first isometrical molecule, however, is the tetratom, giving $C_{20}H_8$, which is the formula usually adopted for napthaline. But it must also tend to form dodecatoms, giving $C_{60}H_{24} = 2\ (C_{30}H_{12})$, as also icosatoms giving $C_{100}H_{40} = 2(C_{50}H_{20})$. The mass seems to consist of both, in variable numbers, corresponding to its variable specific gravity.

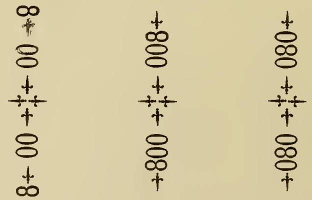
And here, if the student think it worth his while to inquire, he will be surprised to find what a simple system of bodies Laurent's chloro-bromo-nitro-napthalinic what-nots proves to be, if he chose to take C_5H_2 instead of its tetratom $C_{20}H_8$ as the true unit, which undergoes union and substitution. In this way, also, he will be able to explain the large napthalinic molecules obtained by Dumas, Anderson, &c.

The Alcohols.—It is only when the polar elements of a hydro-carbon molecule are atoms of marsh gas—that is, only when they contain a tetratom of hydrogen functioning, as has been shown, like an atom of oxygen—that such a molecule can defend itself against the oxygen and moisture which everywhere prevail in the terraqueous globe. In other cases there may perch on each pole of the hydro-carbon molecule an atom of O or of HO. It is then protected, and is more or less permanent. But now it is no longer regarded as a hydro-carbon. It is an alcohol.

The original substance of this name, which has supplied the generic designation, is derived from the fermentation of saccharine liquids, such as the juice of the grape. Its hydro-carbon is the marsh gas with double carbon poles (see the figures, p. 82), that is, olefiant gas or ethylene, and this hydro-carbon becomes an alcohol when an atom of HO is attached to each pole, and when, consequently, each polar element, considered as a ternary combination, is the saccharine element CHO, which, as a dodecatom $(C_{12}H_{12}O_{12})$, is generally regarded as an atom of sugar.

Now, it is obvious that these three elements C, H, and O may exist united in either of three modes. The polar elements, then, of the atom of alcohol, those parts on which its functioning mainly depends, must be very changeable, as the conditions of existence change. The ingestion of alcohol may therefore be expected to be stimulant or transiently vitalising, and as in none of the three modes of arrangement is the saccharine element poisonous, alcohol, if duly diluted, will not immediately destroy life; while since both its peripheral and its central parts consist of saccharine matter, it may be expected to possess an agreeable taste. Our molecular morphology, therefore, gives reasons why alcohol should play in society the important part which it does.

Its three forms may be represented in our figurate formulæ. The chemical formula of all the three is, of course, the same :—

Alcohol, . .  $C_4H_6O_2$.

The first and the second diagrams are both true alcohol forms; that is, on being poured upon some other chemical, so as after drenching to clothe it, they will each shorten the combined axis by the lapse of the terminal atom of OH or HO into aq, which goes aside, leaving C_4H_5O (the ether element) in union.

These two are also the morphological complements of each other. And the laboratory liquid appears to consist of molecules of both in equal numbers, and thus to be fully differentiated. Now the first, having pentagonal poles, must form into dodecatomic molecules. The second, having trigonal poles, must form into icosatoms. Allowing, then, to the first and smallest half the volume of the second and largest, we obtain as the equation of sp. gr. of

$$\text{Alcohol}\ldots G = \begin{cases} \dfrac{(\text{OHCC}\overset{4}{\text{H}}\text{CCHO})^{12}}{2\text{AQ}} = \dfrac{12 \times 230}{2 \times 1620} = \cdot 802 \\ \qquad\qquad\qquad\qquad \text{Mean, } \cdot 796 \text{ Exp. } \cdot 795. \\ \dfrac{(\text{HOCC}\overset{4}{\text{H}}\text{CCOH})^{20}}{4\text{AQ}} = \dfrac{20 \times 230}{4 \times 1620} = \cdot 741\,. \end{cases}$$

Acetic Acid.—The third form is obviously advanced in solidarity, the polar bodies COC being compact icosahedrons. But the oxygen being thus removed from the pole, this form will be more liable than the others to the attraction of oxygen. Now, if an unit of the oxygen of nature, that is, of oxygen in coupled atoms, attack the poles, the first will lay hold of the terminal atoms of H, and lapse along with them into aq, which will go aside, while the second will fix itself on the carbon poles of the dehydrogenised alcohol (aldehyde), and therewith result—

Acetic Vapour, . . .  $= C_4H_4O_4$.

And here we may remark, in passing, the beautiful rationale which our theory gives of such chemicals as chloral, trichoracetic acid, chloroform, &c. Plainly, they are symmetrical representatives of the same type as the substances we have been considering, only that the three equatorial hydrogens (only two of which we can ever represent) have been substituted by three atoms of chlorine.

As to the anæsthesia which chloroform causes when brought into most immediate contact with the blood by respiration, it does not seem possible to say more at present, than that the structure of the anæsthetic is so stable that it does not tend to spontaneous transformation. Hence it does not stimulate like alcohol, while, at the same time, it presents to the current of life naked single carbon atoms. Now carbon is the deadest, and we should infer that it is the most deadening, of all material elements—deadening not by poisoning or transforming living molecules into forms incompatible with life, but simply by fixing or forbidding the current of life to flow. Were it not for carbon all animal life—if life it could be called—would be quite ephemeral in our planet. Carbon maintains tissue, and so protracts life.

But to return to our acetic vapour. Its atomic weight is 300, while that of a normal volume of common air is about 72. Allowing this acetic vapour a normal volume, therefore, we obtain as—

$$\text{Its Specific Gravity,} \quad \frac{300}{72} = 4{\cdot}16$$

But it is only to be expected that, as the temperature is raised, such a tender structure will dedouble into the truly acid form—

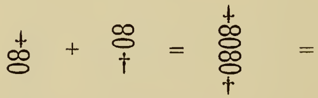
Acetic Acid Vapour,  $= \frac{1}{2}(C_4H_4O_4)$

of which, allowing to it also a normal volume, the specific gravity will, of course, be only half the former—that is, 2·08.

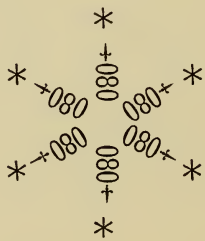
Supposing, then, that when the vapour has acquired power to balance the atmospherical pressure that is at the boiling-point, it has the most fully differentiated and most stable constitution, and consists of both kinds in equal numbers, we shall have—

$$\left.\begin{array}{r}\text{Its specific gravity at}\\ \text{the boiling-point, }\ .\end{array}\right\}\ \frac{4{\cdot}16+2{\cdot}08}{2} = 3{\cdot}12 \text{ Exp. } 3{\cdot}20.$$

It is further to be remarked of the dedoubled form that it has the simplest genesis possible of any substance that shall contain the three organic elements, H, C, and O. Thus, let these three elements, when in union (and these three in union are both the beginning and the ending of organisation), clap together in the simplest synthesis possible, and we obtain—

Its Genesis, . .  $= \frac{1}{2}(C_4H_4O_4)$

And let it become more fully differentiated and more stable by the lapse of HO on the pole into aq, and let the elements of aqHCOC aggregate into a dodecatom (which the twelve atoms of aq will go to moisten all over, as we have seen in the case of glacial sulphic acid, Epsom salt, &c.), and we obtain a molecule whose chemical formula may be written as $6(C_4H_4O_4)$, and which is very probably the molecule of—

Glacial Acetic Acid,  $\div\ C_4H_4O_4$

$$G = \frac{(aqHCOC)^{12}}{AQ} = \frac{12(45+5+100)}{1620} = 1{\cdot}111 \text{ Exp. } 1{\cdot}08.$$

When the peripheral atom of aq betakes itself to the other pole, as HO, the molecule must then form, not into dodecatoms, but into icosatoms; and allowing, as usual, to the icosatom double the volume of the dodecatom, and supposing that the unit of the differentiated liquid consists of an icosatom as the central body, supported by a dodecatom on each pole, we obtain—

Acetic Acid... G = $(aqH\overset{12}{C}OC)\ (HC\overset{20}{O}COH)\ (C\overset{12}{O}CHaq) = 1{\cdot}111 + \frac{1{\cdot}852}{2} + 1{\cdot}111 = 1{\cdot}074$ (the mean).

But possible molecular combinations here are very various, as may be inferred from the capricious densities observed by the balance.

It is important to remark, however, that the constituent element in them all (neglecting the water), and that which ought to be regarded as

The Acetic Principle, is  also the Humic, Tannic, &c.

It is obviously the "Spirit of Salt" (hydrochloric acid), reduced to its simplest terms, the zotic elements being omitted.

The acetic element is, in short, in reference to sodium, what the hydrochloric is in reference to potassium!

Humus.—It enters very largely into the structure of vegetable molecules, such as the tannic acids, gallic, &c., and when it is inverted so that the atom of hydrogen is in the interior of the molecule, and is thus secluded from the attacks of the external air, the poles of the icosatom thus constructed being differentiated by atmospherical elements, it constitutes the molecule of humus, the most stable and last survivor of vegetable nature, which, if left to undergo its own slow decomposition in the moist soil, without some alkaline quickener, is so well known to show its acetic nature by rendering the soil "sour."

	Theory.	Subeiran.	
OCЄ(C$\overset{20}{O}$CH)ЭCO	C...54·4	55·0	From the heart of an aged oak.
	H... 4·3	4·8	
	N... 2·5	2·5	
	O...38·2	37·7	

The Acetic Acid of Acetates.—But if we suppose the dodecatom (see the diagram opposite), to exist in a region where saccharine elements are coupling into acetic, as has been shown, then that dodecatom will certainly take those coupled elements into union with itself, and thus become an acetic molecule with a double wall. Allowing it now a double volume, its specific gravity will be the same as before, and its constituents, instead of being $C_2H_2O_2$, will now be $C_4H_4O_4$. But there is this important difference in its peripheral structure that, instead of being moistened all over by aq, it is covered with HO. Its chemical formula would now, therefore, be legitimately written $HO.C_4H_3O_3$, and on the attack of a protoxide, the peripheral atom of HO would lapse into aq to shorten the axis and go out of the way, leaving as the acetic part of the acetate $C_4H_3O_3$, as is well known to occur. Now this acetic body is a very beautiful structure, consisting of an atom of aq as the coupling joint, with an atom of our elemental acetic principle, HCOC, inserted by its lance-shaped pole H in each of the hollow poles of the atom of aq, which is the medial body.

Acetic Acid, as in acetates,  = { COCHaqHCOC $C_4H_3O_3$.

When this is hydrated by the addition of an atom of HO on each pole, implying that the molecule must thereafter be icosatomic, and granting to so large a molecule four normal volumes, the specific gravity comes out 1·065. But let us not dwell longer on this acid.

Acetyl.—The above, as also everything acetic, the chemist tends to reduce to a form which, having hydrogen both on the poles and the equator, like methyl and ethyl, must function like a single atom of hydrogen, and be very serviceable in the laboratory as being much less volatile than hydrogen—

Acetyl,  = $C_4H_3O_2$.

It is homologous with methyl, which is all that is stable in the first member of the alcohol series, that is—

Spirit of Wood.—As to this member, we obtain the possible secular equation—

Oxygen Gas,  =  Marsh Gas.

Now, but for a certain circumstance, these two ought to unite, and give a beautiful structure,—namely, a dioxide of marsh gas—

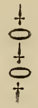
Methylic,  = $C_2H_4O_2$.

But, from what has been said of the functioning of the tetratom of hydrogen, it is to be inferred that the atoms of oxygen on the poles in this case are too near that tetratom for maintaining firmly their position. Hence, as an element for this combination in the molecular state, we may expect among others the beautiful structure—

An element of Methylic Spirit,  $\left\{ \begin{array}{l} \text{HO.CHaqHC} \\ \text{HO.}C_2H_3\text{O} \end{array} \right.$

which, when the atom of HO has gone off, may well form fine polar elements for such a molecule as salicylic acid.

Methyl.—But the liquid methylic spirit is to be expected to consist of many dissimilar elements of the same chemical formula, the ultimate hydro-carbon alone being stable, namely—

Methyl,  = C_2H_3

which, moreover, if set free, will, under the law of sphericity, tend to double into—

Acetene,  = C_4H_6.

Ether.—And here we have the form, which, when it wants the atom of hydrogen on one of the poles, or has that atom substituted by an atom of oxygen, occupies a very important place in chemical systems as ethyl and its oxide, or ether; and that it should do so our theory enables us to understand. Thus, its structure is fine, and it is finely differentiated. Its stability will, therefore, be great. But it is at the same time dissymmetrical and heteropolar, and therefore not insulable by itself (though by coupling it may assume the æriform state which, in consequence of the quantity of hydrogen in it, it will no doubt tend to do). It will, therefore, tend to unite and to remain in union with other substances. And the range of its affinities must be all the greater, for this reason, that it is trimorphous. Hence also in the liquid state it may be expected to be highly differentiated. Its most interesting state, however, must be that in which it is truly an oxide of ethyl, constituting an icosatom in which each of the twenty radial elements consists of five atoms of hydrogen and four of carbon alternating with each other in a linear series, the whole mailed in oxygen, and thus protected, except from hydracids, &c.

Ethyl.—When its elements H and C are arranged in this linear series, this hydro-carbon is not only homologous with methyl, but with a single atom of hydrogen itself; for in methyl, and in all hydro-carbons of the same form in which the atoms of H and of C are more numerous, both the poles and the equator are hydrogens. The entire moniliform structure, therefore, whatever the number of joints of which it consists, must function like a single atom of hydrogen, only it will be less volatile, and consequently less fit for the use of nature, and more fit for that of the chemist. And, indeed, it is amusing to see to what an extent the chemist, constructing the typical hexatom of hydrogen (see p. 17), by the use of methyl, or ethyl, or amyl, or all together, or hydrogen along with either or all, and placing on its poles molecular structures of suitable form and weight, such as azote, phosphorus, arsenic, &c., has succeeded in framing curious toy or mock ammonias, quite unfit for the uses of life indeed, but one of them touching upon nature so nearly as to be found in the brine of the herring barrel. The substitution of these hydro-carbons, in fact, for pure hydrogens, prevents the lapse of the ammonia into its aquaform, and thus secures the construction of the typical structure, the double ammonia.

$NE\overset{4}{H}EN$		NH_2E	Ethylamine.
$NH\overset{4}{E}HN$	÷	NHE_2	Diethylamine.
$NE\overset{4}{E}EN$		NE_3	Triethylamine.
P &c. &c.			&c. &c.
As &c. &c.			

Nay, by the use of iodine, it looks as if the chemist can completely redintegrate the primal type, implying an atom of hydro-carbon on each pole also, giving Me_4 or E_4 in the formula. This is, however, equivocal.

But this field is inexhaustible, and has already betrayed me into details which I did not contemplate when I thought it would be desirable to give the genesis of marsh gas, as showing the genetic relationship of carbon and hydrogen.

Let us return then to page 73, where we began to digress. And what as to the new quasi-halogen there constructed, constituted by the clapping together of

CO	+	COC	+	OC	=	$\dddot{C}_4$.
Carbonic oxide,		Carbonic suboxide,		Carbonic oxide,		Mellic anhydride.

Are we to expect it in this bare state in nature? To this it is to be answered, that since in the terraqeous globe both moisture and oxygen and hydrogen are so abundant everywhere, and the poles of this quasi-halogen are perfect moulds for atoms of O and of HO, and its equator apt for the reception of five atoms of O, so as duly to expand that equator, and bring the form into better keeping with the law of sphericity, we are perhaps scarcely to expect it in its bare state, or as a mere trunk; especially as, in constituting it, no less than eleven atoms of hydrogen have been discharged, which therefore, under the law of redintegration, will tend to re-attach themselves so far as there is accommodation for them.

Honeystone.—Still $\dddot{C}_4$ is found, though rarely, and that in a position of such interest in the economy of nature that even in our rapid sketch it may be mentioned. It appears on the very confines between the vegetable and the mineral kingdoms, giving, we might say, its latest crystals to the latter, and itself as on the eve of becoming undecomposable, like the halogens, silicon, &c.

Gerhardt's formula for honeystone is $C_8Al_2O_8 + 12aq$. Now, though in order to reconcile this formula with other hypothesis, he triples and distributes it thus, $3C_8O_6.2AlO_3 + 36aq$, yet, as first given, it represents a beautifully constructed and differentiated dodecatom, which, allowing it half a normal volume, gives also its own specific gravity. Thus,

$$\text{Mellite, G}\ldots\frac{HO\dddot{C}_4OAl(\overset{10}{HO})AlO\dddot{C}_4OH}{\frac{1}{2}AQ} = 1{\cdot}53 \text{ Exp. } 1{\cdot}55.$$

Here, then, if this view be correct, instead of the sesquioxide, as in the mineral kingdom generally, we have a protoxide of aluminum. And this is what invests this body with such interest. For what, according to our theory of the genesis of the elements, must be the origin of the aluminum here? We have seen that one of the modes of the possible genesis of magnesium (see Molecular Morphology, p. 52) is the metallising and symmetrising of an atom of BO, by which it becomes, first BBeBe, and then BeBBe, that is, Mg. Now, in the same way, if we have C instead of B, we obtain,

$$CO = CBeBe = BeCBe = Al \text{ (see Pl. II. fig. VI.)}$$

And thus, according to these views, the overlong axial body $HO,COCOCOC,OCO = \dot{H}\dddot{C}_4\ddot{C}$ will be secularly metallised at both poles, the pole opposite to H also, and converted into HO,COCOCOC,OAl $= \dot{H}\dddot{C}_4\dot{A}l$. And this theory I touch upon all the more readily, because it gives opportunity of seeing that, though this be not the normal genesis of aluminum, yet it is a possible genesis, giving the equation, Carbonic Oxide, CO = Al Aluminum.

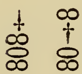
thus indicating, perhaps, from its relation to carbon, of which, according to this view, it has an atom at heart, why this metal should be, as it is found to be, an indispensable constituent of a fertile soil.

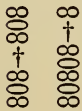
The same theory leads us also to infer that our quasi-halogen $\dddot{C}_4$ (mellic anhydride) is the most lengthened combination of atoms of carbon and oxygen on the same axis which nature tends to conserve; for where the axis is longer, we have seen that the extreme elements tend to be metallised and transformed.

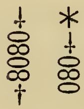
The Vegetable Acids.—And here we may notice the whole of this series, all the members of which are indeed derived from our two primal combinations, CO and COC, merely with the addition of moisture and hydrogen. It may be easily seen that they are the elements of which the principal vegetable acids are built up. In chemical works, indeed, these acids are signalised each by its own formula, which in each acid is considered to be always the same. And in order to meet the very varied phenomena which each particular acid displays in its functioning, there has been invented the hypothesis of monobasic, bibasic, tetrabasic, hexbasic, &c. But such conceptions are phenomena of human ingenuity merely. These acids, by doubling or dedoubling, by acting singly or in the molecular state, are capable of suiting themselves to the conditions of their existence, to a degree which is the very counterpart of those stereotype formulæ which chemists prescribe for them.

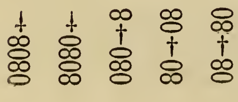
The elements of the principal vegetable acids are—

 $= \frac{(CHO)^{12}}{12}$ The Saccharine Element.

 $= \frac{C_2H_2O_4}{2}$ The Formic Element.

 $= C_2HO_4$ The Oxalic Element.

 $= \frac{C_4H_4O_4}{2}$ The Acetic Element.

 $= \frac{C_4H_2O_4}{2}$ The Malic and Citric Elements.

$$= \frac{C_8H_4O_6}{2}$$ The Succinic Element.

$$= \frac{C_8H_4O_{10}}{2}$$ The Tartaric Element.

Tartaric Acid.—Very many and beautifully various, as may be inferred from what has been already said of acetic acid, are the ways in which these oxy-hydro-carbon elements may advance their own synthesis by uniting among themselves, as also by uniting with one another, and with aqueous matter and bases.

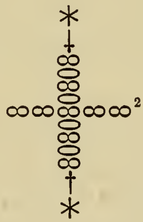
As to the last in the series, its modes of union and of existence cannot but be very many. And, accordingly, its chemical investigation has been found to be very puzzling. It appears to be constructed in nature either around a particle of water AQ, or a molecule of potass $(KO)^{12}$, as the nucleus. The first gives the pure acid, which is not unfrequently found in nature. But most usually the elements of this aqueous acid form around a molecule of potass. Now, being moistened with aq all over, it will act like a particle of AQ, so that a second coating of acid will form on it; an atom of aq thus forming a coupling joint between two elements of acid with hydrogen poles, giving rise to a beautiful structure, such as we have seen in acetic acid. The formula of the element of the fully constructed salt will therefore be—

$$\text{Tartar,} \quad HO\overset{\cdots}{\underset{4}{C}}OHaqHO\overset{\cdots}{\underset{4}{C}}OHOK = KO.HO.C_8H_4O_{10}.$$

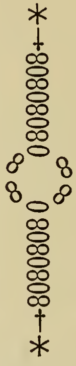
Hence, it has been inferred by the chemist that the pure acid is $2HO.C_8H_4O_{10}$, and that the neutral salt is $2KO.C_8H_4O_{10}$, and on this, as the type, the attempt has been made to interpret every phenomenon which this acid displays. But even with all the insight which our molecular morphology imparts, with its dodecatoms, icosatoms, aquaforms, and its doublings and dedoublings, it will be long before the acid of tartar and the others confess all that they are, or may become, under the torturing of the laboratory.

Carbonic Acid.—The tartaric element is very axial or prolate. When oxygen abounds, therefore, it will tend to secure the incidence of five atoms of oxygen around its pentagonal equator, and so to bring its form into better keeping with the law of sphericity. And when more powerful bases are absent or withdrawn, it will take an atom of aq on each pole. Thus we shall obtain the first of the acids figured beneath.

But, as has been stated already, and as holds in reference to all structures of the same type, the five atoms of oxygen on the equator do not stand evenly out in the plane of that equator. They all decline towards one pole. Under the law of symmetry and sphericity, therefore, such acid elements must tend to couple, since by so doing they can construct a finely differentiated dodecatom, from the centre of which the aqueous matter previously on the poles, now become the equator, will no doubt be excluded. There will thus result, as the culmination form the second of these figures—



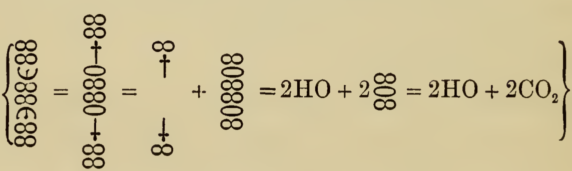
$C_4O_8 + 4HO.$



$C_8O_{16} + 4HO.$

But here an interesting fact presents itself. If, instead of pursuing our synthesis in connection with the highest products of vegetable nature, we go back to our Plutonic abyss, supposing that now there is abundance of oxygen along with the other elements which we were led to look for immediately after oxygen, we obtain carbon and oxygen united in the same ratio as here, but with this difference, that there we have the structure as a minimum, whereas in vegetable nature, as just conceived, we have it as a maximum. There we obtain every single atom of carbon lodged in the cavity that exists between a coupled atom of oxygen, that cavity being a perfect mould for the atom of carbon. In a word, commencing with a dioxide of lithia, we obtain (see p. 72) the following equation, issuing in a dioxide of carbon :—

Dioxide of Lithia,



Dioxide of Carbon.

Now, whilst in a primal region of genesis we find carbon, according to our theory, given to nature in this state, there is much to admire in that state. Thus the element of oxygen gas in this dioxide, though its stomach be charged with carbon, is isomorphous, and doubtless isovoluminous with its former self. It might be called carboxygen. And while, on the one hand, its stomach being already filled with carbon, it will not care for more, being æriform, it must be an admirable carrier of carbon in single atoms into concretes; for the oxygen which encloses it, though it has lost its taste for more carbon, will not have lost that parasitic habit which attaches to its form. And, therefore, we should expect to find this kind of air to be like oxygen itself, a fixing and a fixed air, only with this difference, that the coupled atom of oxygen now cannot open, so as to leave the surface where it settles down as a protoxide. That surface must take and hold all the three elements of which the atom of dioxide of carbon consists as an unity. And thus, after protoxides, and in union with them, we shall have these elemental carbonates. And here we have occasion to remark a great morphological gain which has been made by this step in synthesis. In a word, a sesquioxide has been constructed, that is, an element in such symmetrical relationship with oxygen that it consists of an atom of this element in the equator, and an atom on each pole. Thus, taking the letter X to stand for any metal, we obtain as the single element of

A Carbonate, OCOXO $=$ $XO.CO_2$.

The question is, then, whether, looking to this primal genesis and the morphological perfections of this ($OCO = CO_2$) dioxide of carbon, we can expect that our differentiated dodecatom, in which the ratio of oxygen and carbon is the same, shall keep together as a dodecatom, except under greater pressures or degrees of cold than are necessary to preserve similar structures in other cases. This is a question which cannot at present be answered by morphological deduction. But to me it appears that the phenomena displayed by this most important agent at the earth's surface would be happily explained, if we assume that this true acid can subsist in water, especially under pressure, and when the temperature is not too high, and that when the dioxide has entered into the composition of a concrete, it tends to grow into this true acid. By supposing that this true acid exists and acts when in water, we are able to understand the solvent power of carbonic acid, which is so great that scarcely any rock can altogether resist it; for its atomic weight is no less than 194 when $H = 1$. Moreover, by assuming that earthy carbonates, while they become crystalline or organic, are rising to the more perfect molecular state, we take a view which the analogy of nature supports.

It is also remarkable that, supposing the dodecatomic structure to have been completed, both in acid and base, the united structure must still be of the sesquioxide type. And the growth of individualised elements and their culmination in a calcareous mass, would consist in the substitution of the sesqui-combination in dodecatoms instead of that in single atoms. Thus, using the symbol $\bar{C}$ for $\overset{\cdots 10 \cdots}{\underset{4}{C}O\underset{4}{C}}$, we should have as sp. gr.—

$$\left.\begin{array}{ll} \text{Crude Limestone, .} & \dfrac{((OCOCaO)^{12})^{12}}{\frac{1}{2}\text{ Ice}} \\ \text{Calcite, Pearl, \&c.,} & \dfrac{\bar{C}\overset{12}{(CaO)}\bar{C}\overset{12}{(CaO)}\bar{C}}{\text{Ice}} \end{array}\right\} = 2{\cdot}77 \text{ Exp. } 2{\cdot}77.$$

and similarly without the lime—

$$\left.\begin{array}{ll} \text{Concreted Carbonic Gas, .} & \dfrac{(OCO)_{12}}{AQ} = \\ \text{Crystalline Carbonic Acid,} & \dfrac{\left(\overset{\cdots 10 \cdots}{C_4OC_4}\right)}{8AQ} = \end{array}\right\} {\cdot}815 \text{ Exp. } 8 +$$

Sponge, Shell, and Bone Acids.—But what imparts to this investigation as to the culmination state of carbonic acid an interest to justify so many words, or to introduce it in so rapid a sketch as we are now giving, is the light which it throws upon the molecular state of the earthy matter which is introduced into animals to support their otherwise too soft or yielding forms. It is generally supposed that this earthy matter is introduced into animals of the simplest organisation merely as SiO_2, that is, as silica; in those whose organisation is more advanced as $CaO.CO_2$, carbonate of lime, and in those of the highest organisation as $3CaO.PO_5$, phosphate of lime. Now, between these three molecular structures there seems no analogy at all. Our theory, on the contrary, leads to the inference that, in all the three, the acids are isomorphous and isovoluminous, nay, possessed of the very same structure, and that the structure which has been assigned to carbonic acid—

Silicic Acid, .	$\overset{\cdots 10 \cdots}{\underset{4}{Si}O\underset{4}{Si}}$	=	$8SiO_2$
Carbonic Acid,	$\overset{\cdots 10 \cdots}{\underset{4}{C}O\underset{4}{C}}$	=	$8CO_2$
Phosphoric Acid,	$\overset{\cdots 10 \cdots}{\underset{4}{B}O\underset{4}{B}}$	=	$8BO_2$

The oxygen-form in the last being composed, not of five hylogens, but of five hydrogens, packed in between four atoms of boron, and the whole so consolidated as to be undecomposable in the laboratory. And that we may reach this most interesting substance, we shall soon make a few remarks on boron. But here yet a few more on carbon.

CHAPTER IX.

THE TISSUE ELEMENT.

Having become so far acquainted with carbon, we may now look for a moment at the tissue element, that structure with which, when built up into an organism, we find life palpably associated. That carbon should be essential to its construction we can easily understand, for otherwise tissue consists of elements which are ever tending to assume the æriform state, while, for the purposes of individualised life, they must be detained in the concrete form. Now, for this purpose, no known element seems so suitable as carbon, for it is always at hand, and no other element is of so fixed a nature—none so well suited for bolting together and holding fast any structure into which it enters.

But while thus valuable in rendering a concrete tissue possible, and so in preserving the existence of the individual by postponing its vaporisation, carbon is to the same extent acting in opposition to the interests of life in general, for life in general consists in motion and change. In itself, carbon is the very principle of sleep, of death. And thus, as in medicine so in nature, the individual lives of all organisms that live may be said to be sustained by a system of considerate, well-tempered tonic treatment applied to all.

But what are the elements which thus require to be narcotised by carbon, or kept down, so that the flame of life may not burn too fast away? They are commonly enumerated as oxygen, hydrogen, and nitrogen. But our morphology leads us specially to view them rather as these elements in union with one another, and specially what we may call the single and the double vapour, that is, common vapour and ammonia (see Pl. I. fig. xi. aq, and Pl. II. fig. x. am). So like, indeed, in form and structure is am to the double of aq, that in our figurate formulæ they ought to be represented thus—

Common Vapour, ✳   ✳✳ (one above the other) Ammonia.

But in the atom of ammonia both atoms of aq have been modified in a remarkable manner, as we shall presently see. Moreover, they are not merely resting on each other at the poles, but bolted together by an atom of hydrogen extending between the centres of both. It will be advisable, therefore, though in reality that medial atom of hydrogen neither appears externally, nor adds to the length of the axis, to write the formula of

Aquæform Ammonia, $\begin{array}{c} * \\ \dagger \\ * \end{array}$

And now let us bring our theory to the rescue of the admirable Liebig, who, though he could not at all explain it, yet found it necessary to assume that ammonia was a truly primeval substance. Let us ascend again into the upper regions, and, as in order to the genesis of moisture there, we assumed the pre-existence in those regions of matter in its most fully analysed state, the state of mere units along with hydrogen (see p. 17), so now let us assume the existence of the common vapour thus generated along with hydrogen. Then, since the atom of hydrogen has, as has been shown, five points for union, just as before (for the genesis of the atom of common vapour) we obtained $H\mathfrak{H}_5 = aq$, so now we shall obtain Haq_5, that is, an atom of aq on each of the poles of the atom of hydrogen, and three on the three edges of its equator—

Nascent, $\begin{array}{c} * \\ * \dagger *^{2} \\ * \end{array}$ Terhydrated Ammonia.

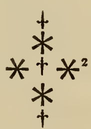
But in this same region where we are now, we have already obtained a combination very similar to this (see p. 22), consisting of six atoms of moisture, from which we have seen that the aqueous element in all its forms results. It is interesting to compare that with this, in relation both to the conditions of stability and the law of symmetry and sphericity. Doing so, then, we may say that this possesses greater stability, the two atoms of aq which form the poles being bolted together by the doubly-lance form of the axial atom of hydrogen; while in the other, that is, in the wholly aqueous structure, they are merely poised on the summits of an atom of aq, which forms the centre of that structure. But, under the law of sphericity, this hydro-aqueous structure is not so good as the purely aqueous structure. Its axis is too short for the breadth of its equatorial diameter. Under the sustained operation, therefore, of the law of sphericity, the axis will tend to lengthen, and it will lengthen, if the law of symmetry permits. Now, on inspecting the structure of the centre of an atom of aq, it will be seen that the law of symmetry has by no means completed its work there. Thus, the units there are disposed in two groups,—one group consisting of six, which is the number determined by the symmetry of the whole structure, and essential to it; the other group consisting of five, which impair the symmetry, and which, in a word, are supernumerary. Here, then, in the terminal poles of the two atoms of moisture, which are bolted together by the atom of hydrogen, is the material for the forthputting of an atom of hydrogen in each. Moreover, these poles being hexagonal, are also trigonal, and therefore admirably suited for developing and holding these hydrogens thus protruded.

Meantime, by the emission of these hydrogens from the two atoms of aq, the latter have been profoundly modified. Their centres have, in fact, been reduced so that each of the five hylagens constituting them has now lost an unit from its equatorial angle. These hylagens are now bound, therefore, to keep together united as they are, to the end that all may supply the deficiency of each. They can no longer part company even for a moment, as atoms of hylagen in aq do, when they are to be turned round into the O of HO. In this case they can only be transformed into an atom of zote, and the atom of reduced moisture, instead of an atom of

Moisture  can only give an atom of  Hydro-zote,

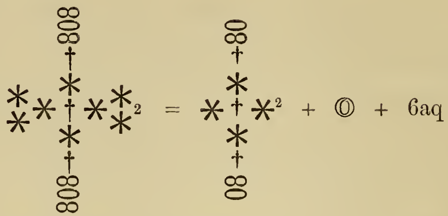
and, therefore, plainly the two atoms of reduced vapour bolted together by an atom of hydrogen, if decomposed by electricity or otherwise, must give us three atoms of hydrogen along with one of azote; that is, they indicate the pre-existence of an atom of ammonia.

The Genesis of Tissue.—But in order (for the sake of the chemical reader) to bring out this result, we have been going too fast. We first obtain, possibly in the azure, the following equation—

Haq_5  =  $\left\{ \begin{array}{l} AmH_2aq_3 \\ \text{or } AzH_6aq_3 \end{array} \right.$

And now, if carbonic acid gas should come in the way, we may reasonably expect an atom of it to perch on each pole constructing formiate of ammonia. But now the length of the axis is too great for the breadth of the equator. In order to extend the latter, therefore, more moisture will be added in the equatorial plane. But the addition of only six aq, the smallest number which the symmetry of the equator admits, over-extends that equator so that the entire structure has now become highly oblate. Like the tetratoms of hydrogen, therefore, it will act negatively and repulsively upon the oxygen in the dioxides of carbon on the poles (see p. 16). And thus there may result the equation—

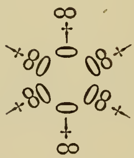
Hydrated Formiate of Ammonia,



An Ammonia-syrop, Oxygen gas, and Moisture.

Now this, if it form into molecules first round one pole and then round the other, will give two atoms of sugar, or one atom with double walls, and set free, as the medial structures, twelve atoms of terhydrate of ammonia.

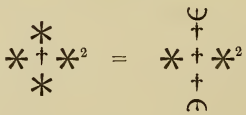
The simplest Sugar,



$C_{12}H_{12}O_{12}$.

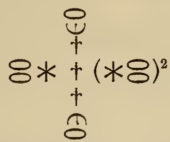
But, by this abstraction of its polar saccharine elements, the form of the terhydrate of ammonia, which remains, is as at first oblate. Its axis is too short. Can it not then extend it without waiting for more matter to be added to it? Yes; we have seen (see p. 60) that the atom of ammonia is beautifully dimorphous; and, in one of its forms, the axis is much longer than in the other. This transformation of the axial and ammonical part of our structure, therefore, may be expected to take place. And thus we shall have the equation—

Terhydrated Aquæform Ammonia,



Terhydrated Hydro-zotic Ammonia.

Now, in the latter the form is prolate. This swinging of the pendulum of form on both sides of the spherical, the form of repose, we have constant occasion to observe. The equator of our hydro-zotic ammoniacal hydrate is in want of extension, and, as we have already seen, the number of elements which the symmetry of the equator requires is six. In the places, then, of the six atoms of moisture, which were there before, let six atoms of carbon be applied, and the equatorial part of the structure will have acquired a certain amount at once of stability and of extension. The axial part will also be secured in its position. But there is nothing as yet to prevent this part from alternating between the aquæform and the hydro-zotic, and therefore from extending and contracting through a certain range. But its zotic poles cannot be long free in a region where free atoms of carbon may come in the way. These poles will take and hold one atom of carbon on each. And, when thus fully charged with carbon, what, let us ask, is the formula?

Element of Muscle,  $C_8H_6NO_3$.

Now such is precisely the formula which C. Schmidt obtained for the dead muscular tissue as taken from insects, creatures in which that tissue exists in such extraordinary perfection!

But we found that these elements thus agreeing with the muscular were simultaneously disengaged in sets of twelve. These, therefore, in their turn, will tend to be constructed into a dodecatomic or an icosatomic molecule, according as C or H is centrad. Now, of such a molecule we obtain the following as the chemical formula, when C is centrad—

$$\text{Proteine,} \quad C_{96}H_{72}N_{12}O_{36} = 2(C_{48}H_{36}N_6O_{18}) \quad \text{Scherer.}$$

But when H is centrad, as it may be when more moisture, HO, is present, they will form into icosatoms, and then we shall have,

$$\text{Proteine,} \quad C_{160}H_{120}N_{20}O_{60} = 4(C_{40}H_{30}N_5O_{15}) \quad \text{Mulder,}$$

there being only slight differences in the quantity of O or of HO between these and the chemical formulæ, as is only to be expected, since the drying process of the chemist is something quite conventional.

But the true unity, which is the basis of the organisation of muscle, &c., is that which C. Schmidt analysed when existing in its fixed and fully carbonised state. Now as to its trigonal, that is, its aqueous and ammoniacal matter, it is all derived from one atom of hydrogen saturated or fully charged with moisture, namely, Haq_5! And as to its pentagonal matter, that is, its carbon, it is all supplied by exhausting of its carbon one atom of our carbonic acid!

$$\underset{\text{Moisture.}}{Haq_5} + \underset{\text{Carbonic Acid.}}{\overset{\dots 10 \dots}{\dot{C}_4O\dot{C}_4}} = \underset{\text{Tissue.}}{\left\{ \begin{matrix} C_8am.aq_3 \\ C_8H_6NO_3 \end{matrix} \right\}} + \underset{\text{Ozonohydric Acid.}}{HO\overset{12}{©}OH}$$

It may be said, then, that the elements provided for supplying the most highly vitalised organism in the world—that organism which shall be suitable for effecting motion this way or that way in obedience to the dictates of a Will—are hydrogen and common vapour, constructing terhydrated ammonia, obtained from above, and sodium and oxygen, constructing carbonic acid, obtained from beneath, the latter breaking up in the presence of the former, and giving its carbon to it so as to bind down the combined vapours on the surface of our planet as elements of tissue.

And here our theory presents us with a very interesting phenomenon. In fact, it suggests a carbonic alkali as well as a carbonic acid! It suggests a structure having two mellic elements as poles, with a hexatom of hydrogen for the body. But it must be very tender. And being decomposed, it gives the following equation—

$$\text{Carbonic Alkali,}\quad \overset{\cdots}{C}_4\overset{6}{H}\overset{\cdots}{C}_4 = 8C + 6aq, \quad \left\{ \begin{array}{l} \text{8 single atoms of Carbon} \\ \text{plus 6 of moisture,} \end{array} \right.$$

that is, it gives all the carbon simultaneously required for the construction of an element of tissue, and all the moisture!

Muscular Action.—And now, by constructing molecules of such tissue elements, and rendering them continuous by allowing only one atom of carbon as common to two in the region where they touched, we might flatter ourselves with the belief that we had obtained a structure something like that of the ultimate contractile and extensile fibre. But we are certainly, while amongst mere elements, at an immeasurable distance from everything that is visible even in the highest powers of the microscope. Nevertheless, such constructions are not in vain. If true within their own sphere, and rightly interpreted, they do not mislead.

The course of nature is consistent with itself from first to last.

The structure, which we are now associating with the tissue of living animals, had its basis laid in the azure of the sky. It had been provided for and foreshadowed in the sunny clouds of the first morning. So deep beyond his own conception was the truth, which Haller uttered, when he said, "Ab ovo omnia;" and so true the utterance of the inspired poet, when, referring to the Creator of the world, he said that "He created it not in vain—He formed it to be inhabited."

The Transformation of Tissue.—With regard to our tissue element and fibre, if, through its continued action (contraction and extension), the polar elements should be detached and thrown out, that which would be the common excretion of two adjacent molecules, and which being symmetrical might, when detached, exist separate, would be—

$$= CNH_2.$$

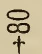
Now, from what we have seen of structures of this form, with hydrogen poles, we know (see p. 73) that they must tend to double, so as to construct a tetratom of hydrogen as the medial body. Let these rejected tissue-elements double then, and in order to secure them from the further attacks of oxygen, that ubiquitous parasite, let them receive and fix an atom of oxygen on each pole as usual, and we obtain—

Urea,  $= C_2H_4N_2O$

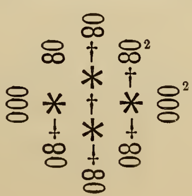
Thus it appears that our extensile and contractile filament in contracting and suffering solution of its continuity, must in doing so throw off urea as the product of the lesion, transformation and oxidation of the polar elements, while, with regard to the carbon of the equator, oxidation must carry it off as carbonic acid gas.

And thus, in our morphology, the renal and the respiratory functions present themselves as the orderly complements of each other!

Dermo-Skeleton Tissue.—In being easily transformable and quick for the purposes of life, such a structure as that which has been just described must necessarily be very tender and easily destroyed. But in order to sustain the forms of organised beings, and to afford fulcra to which the soft parts may be attached, some stable inflexible structure is obviously needed. Now we have seen, with regard to our tissue element, that as the carbon is increased that tissue tends to become more stable, the question therefore occurs, may not the carbon be increased until tissue become so stable that it may serve as material for maintaining the animal form? Now, in answer to this, it at once appears that if it be stability which we are seeking in a structure in which there are aquæform poles, and in our structure (when in a state of contraction) there are no fewer than 8 such poles, it is not simple atoms of carbon, but it is the nail-shaped combination of COH, that is, carbon in union with HO, which we are to look for, namely,

Saccharine,  $= COH.$

There is, moreover, on each of the three atoms of aq, on the equator of our tissue element, a space between the two atoms of carbon fixed there already, which is suitable for receiving another single atom of carbon, thus raising the number of atoms of carbon on the equator from 3×2 to 3×3. Now, this done, there results a structure of exquisite stability and beauty, whose chemical formula is precisely that of

Chitine,  $= C_{17}H_{14}NO_{11}.$

Thus our theory reaches that exquisite material of which the dermo-skeletons of insects and many other tribes are constructed.

Phyto-Cellulose.—As to the structure of the vegetable kingdom, the ammoniacal and the aqueous no longer exist in general in such close relationship. In this realm the axis of the tissue-element, instead of being am with aq placed around it, is aq solely. But on this subject I will not enlarge, contenting myself with referring to what I published upon it nearly ten years ago.* Let it not be inferred, however, that there is any essential difference between the truly living parts of plants and of animals. In the truly living parts of plants the primary utricle exists within the cellulose of the cell. And by all that can be learned of it, the structure of the tissue-element which constitutes the primary utricle is the same as the tissue element in animals. The investing cellulose may be regarded as an organic incrustation or dermo-skeleton, imparting to the vegetable kingdom greater stability, but with the loss of that mobility which is the indispensable condition of animal life.

That this incrustation of cellulose on the living cell may be prevented, and the animal kingdom be thus saved from lapsing into the vegetable, I have elsewhere endeavoured to show that the hepatic function has been instituted in animals.†

The Albumenoid Bodies.—I only add, that the tissue element, by the transformation of the lateral atoms of aq into HO, and the transference of the 6 atoms of carbon from them to the ammoniacal axial body, proves itself exquisitely dimorphous, and capable of a form in which it may be stored up almost secure from decomposition. By this transformation we are carried in amongst the albumenoid bodies, for some insight into which see the work just referred to, page 102 *et seq.* I had not, indeed, at that date, ascertained the true nature of phosphorus, and my views in other respects were defective when estimated from the stand-place of the work now in the reader's hand, which records my study during the leisure of another decade of years.

* See "First Lines of Science Simplified, and the Structure of Molecules. Attempted by John G. Macvicar, D.D. Edinburgh: Sutherland & Knox, 1860."

† See Edinr. Med. Journal, vol. xiv. p. 131.

CHAPTER X.

BORON; PHOSPHORUS AND ITS ISOMORPHS, ARSENIC, VANADIUM, ANTIMONY, BISMUTH.

The secular or specific heat which actuates all molecules unremittingly, and at all temperatures, must, from its very nature, tend to rarify them. And since this rarefaction must always take place under the sustained operation of the law of symmetry and sphericity, it must often give rise to beautiful developments. And it may be shown that, in the case of oblate forms like that of the atom of carbon, when they cannot attain to the spherical by pairing on the same axis, each will tend secularly to attain this end by dedoubling in order to be doubled.

Boron (Pl. I. fig. IV. B).—A single atom of carbon may be developed into two atoms, both isomorphous with the atom of carbon itself, and with one another. This transformation we may, in the meantime, express by the secular equation,

1. Carbon,  =  2 .β. Boron (monatomic).

It is further to be remarked, that the atom of lithhium, which we have already found to be the most important of genetic principles after the bitetrad itself, may attain to symmetry otherwise than by giving off two atoms of hydrogen, and being in this way reduced to an atom of carbon. It may attain to symmetry without reduction, and simply by the closing up of its five-fid or metallic pole, while it opens simultaneously at the equator. In this way there results the equation,

1. Lithhium,  =  2 .α. Boron (monatomic).

In this case, however, the borons obtained are heavier by an atom of hydrogen than the isomorphs obtained by the dedoubling of the carbon. Each of the latter obviously weighs $\frac{40}{2} = 20$, while the former weighs

$\frac{30}{2} = 15$. Here then, analogously to hydrogen and hylagen, which are our most elementary *trigonal* elements, we have two elementary *pentagonal* elements, the one with single, the other with coupled units in each of its equatorial angles.

In the actual chemistry of the day, the first symmetrical combination of these two borons has been regarded as a single atom, which has been said to be "triatomic," its functioning thus so far suggesting its true nature, its atomic weight, consequently, $4 + 3 + 4 = 11$, when $H = 1$.

Triatomic Boron, $B^{111} = 3B$ Monatomic Boron.

But by adopting the view of boron here given, it will be found that chemistry is relieved of one of its heaviest chapters,—in which, indeed, there is an unusually frequent use of the screw to twist the phenomena into seeming accordance with the hypothesis of a triatomic boron.

But neither of the modes which has now been mentioned gives what must be regarded as the characteristic genesis of our boron in nature. That genesis is the emission of boron instead of hydrogen, the pentagonal ultimate element instead of the trigonal, when baric and barytic elements are symmetrising themselves, or undergoing secular evolution and partitionment. Thus, while in the light and the common lithhium there are in the five summits of the five-fid pole only five units, that is, only the material for constructing an atom of hydrogen, in baric and barytic lithhiums, on the other hand, there are five tetradic units = five times four units, that is, the material for constructing an atom of boron. And this boron they will, on being disengaged, undoubtedly construct, in preference to an atom of baric hydrogen (which they might also possibly construct), because hydrogen is trigonal, while boron is pentagonal, and the material, when existing in the lithhium form, is pentagonally arranged already.

From this source we shall see, as we proceed, that there is provided for nature, as the secular development of baric and barytic molecules proceeds, not only an abundant supply of silicic (see p. 54), but also of phosphoric acid, for the world of living creatures; for four borons, as we shall presently see, when welded together by light oxygens ($= H_5$ instead of Ħ_5), as the coupling-joints, constitute phosphorus.

Boric Acid.—An atom of boron, in union with an atom of O and one of HO, escapes into certain volcanic lakes, from which there also escape gases, of which upwards of 91 per cent. are carbonic acid gas. Such is sassoline. Let us suppose that it has been generated by the expansion of carbonic acid gas, retained in dodecatoms and in the volcanic and aqueous abyss, by being fully hydrated by aqHO on each of its twelve constituent members, we thus obtain—

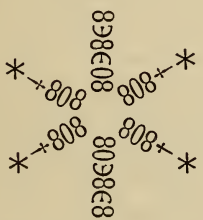
$$\text{Carbonic,}\quad (aqHO.OCO)^{12} = (aqHO.OBBO)^{12} = 2(BO.HO)^{12}\quad \text{Boric.}$$

That it is the light boron, its atomic weight, 15, *i.e.*, 3 when $H=1$, which enters into the constitution of this natural substance, is shown by the specific gravity experimentally obtained. Thus,

$$\text{Sassoline,}\quad \frac{2(HO.BO)^{12}}{AQ} = \frac{12(90+110)}{1620} = 1{\cdot}48 \text{ Exp. } 1{\cdot}48.$$

But such a molecular structure is in the highest degree reduced. And considering that the primitive genetic element both of carbon and of boron, is lithhium, and that of lithhium the most stable combination is the undecomposable suboxide, that is, sodhium, what we are to expect in nature is not so much pure boric acid as boric acid in union with soda.

Borax.—Of this interesting salt the most recent formula which I have seen (see "Dictionaire de Chemie," par Ad. Wurtz, tom. i. p. 652) is $B^4O^7Na^2 + 10H^2O$. This becomes to us $B^{12}O^{14}Na^2 + 10aqHO$. And this presents to us a finely differentiated dodecatom, moistened all over by aqHO, of which, however, the aqH (which, to keep up the analogy of ammonium, chemists should call aquium) is substituted on the poles by one atom of Na on each.

Borax,  $= ONaBO(aqHOBO)^{10}OBNaO$
$= 2(NaO.2BO_3 + 10aq)$. Auct.

Allowing it to form, as usual, into differentiated dodecatoms, and these into composite dodecatoms, each occupying eight aqueous volumes, or half an ice volume, we obtain,

$$\text{Borax, G}\ldots\ \frac{(ONaBO(aqH\overset{10}{O}BO)OBNaO)^{12}}{8AQ} = 1{\cdot}73 \text{ Exp. } 1{\cdot}72.$$

Our two borons, however, are chiefly interesting from the part they play when existing in undecomposable union with other elements, especially the oxygen-forms, all the members being piled on the same axis. That such combinations shall be generally undecomposable may easily be granted, since the two constituents are doubly convex and doubly concave lens-forms respectively, all of the same radius, and such that they fit into each other like the members of an achromatic lens or vertebral column. But to proceed with the most important members of this series.

Phosphorus, Vaniadium, Arsenic, Antimony, Bismuth.—With regard to the first of these, namely, phosphorus, which is the most interesting of them all, it may be shown that it may have either a meteoric, an oceanic, an organic, or a mineral origin, and that it may be expected to be found diffused through all nature, while yet it is not easy to compass its genesis otherwise than in a many-worded investigation. I allude to that element which shall possess the same structure as the polar elements in our carbonic acid, $\underset{4}{\dddot{C}}$, but which, instead of being constructed of common carbon and oxygen, and being decomposable, shall be constructed of boron and light oxygen, and shall prove itself to be undecomposable in the laboratory. It cannot but be very interesting, because it may be shown that the four atoms of full-weighted boron which it contains will tend to suffer reduction into light borons, during which the material units which make the difference will tend to be given off, not as usually in atoms of hydrogen, but in single units, which leaping into the medium of light while the process of reduction is going on, may be expected to render this substance eminently luminous or phosphorescent as compared with others. It is also interesting, in consequence of the great length of its axis, whence it must be an element of great chemical activity generally and especially in its demand for oxygen, since it consists in so great measure of hydrogen and boron.

But, as I have stated, experiments are not to be found which might be adduced to verify the successive stages of its construction. Let us, therefore, take together the five elements which are named at the head of this paragraph. Chemists are agreed as to the great similarity of functioning in all of them. This suggests that they all possess the same form and structure. And if, by recurring to that feature in our theory which gives isomorphic molecules of various kinds, whose atomic weights are inexorably fixed by that theory, we obtain, by the same construction in reference to all the five, the very atomic weights which are given in the tables in chemical works, this must surely prove that our construction is something else than a mere play of imagination.

The type which, in virtue of its easy decomposability, led me to the discovery of the structure of the series, is the polar body in dodecahedral carbonic acid, which, however, in honey-stone is secularly consolidated so as to be nearly undecomposable—

Mellitic Anhydride,  $= C_4O_3 = \underset{4}{\dddot{C}}$

The materials for construction into the cylinder-shaped elements now to be tabulated, are the lens-shapes, doubly-convex (carbon shapes), and the doubly concave (oxygen shapes). They differ from each other in atomic weight by one atom of common hydrogen when they are "light," that is, by five units of weight and by one atom of baric hydrogen (or boron), that is, by twenty units when they are baric or barytic. We thus obtain—

	Oxygen form.				Boron form.
5 × 5 Light, . . .	25	} −	5	=	20
5 × 8 Common, . .	40				35
5 × 20 Baric, . . .	100	} −	20	=	80
5 × 32 Barytic, . .	160				140

It will be remarked that there is here a series of only four terms, while in that beneath there are five. But this difference is explained when the structure of arsenic is looked into, which will be seen to be composed of two orders, viz., light and baric,—

		H = 5.	H = 1.
Boron and Light Oxygen, . .	20 + 25 + 20 + 25 + 20 + 25 + 20 =	155 =	31 Phosphorus.
Of Common Weight, . .	35 + 40 + 35 + 40 + 35 + 40 + 35 =	260 =	52 Vanadium.
Boron and Fluorine, . .	20 + 100 + 20 + 100 + 20 + 100 + 20 =	380 =	76 Arsenic.
Baric Boron and Fluorine,	80 + 100 + 80 + 100 + 80 + 100 + 80 =	620 =	124 Antimony.
Both Barytic, .	140 + 160 + 140 + 160 + 140 + 160 + 140 =	1040 =	208 Bismuth.

If it be asked why, with the exception of the first, they should all have a metallic aspect, while our genesis gives them as metalloids, the answer is that the three oxygen-forms, which form the coupling joints in each, must all secularly become metallised, except phosphorus, in which the oxygen-form has not matter enough to compass this transformation. Thus, common oxygen in such a situation must secularly tend to become wholly cellular, by the inversion of the ten tetrads of which it consists, and so to be transformed into a metallic annulus.

Baric oxygen, or unreduced fluorine, under the secular operation of its specific heat and the law of sphericity, must tend to give the following equation :—

Baric Oxygen or Fluorine, $F = \mathbf{H}_5 = H_{20} = Ca$, Calcium,

so that for this most terrible element there is provided ultimate repose in nature by the transformation of

Fluorine Gas, FF = FCa, Fluor spar.

Barytic oxygen, also, which, as might be expected, still conceals itself from the chemist more successfully than fluorine, gives—

Barytic Oxygen or Tetroxygen, $= Ḫ_5 = Ḫ_{20} = Zn$ Zinc.

It is no wonder, therefore, but it is precisely what our theory would lead us to expect, that all the members of the preceding series, except the first, should have a metallic aspect, and be commonly regarded as metals. They must, however, according to our theory, be all of them brittle, for the absence of five-fid poles prevents their locking into each other, and being ductile. To remind of the metallic bands, then, of which there will be ultimately three in each, we may give the following figurate formula as the type in which the summits of the tetrads in the oxygen-forms have been inverted, and are now peripherad,

Antimony, &c.,  showing metallicity.

And here we may remark, that the same metallisation of the medial atom of oxygen in the structure of the alkalies and halogens will tend to take place, so that we may represent

Potassium, &c.,  and  Chlorine, &c.

But when this metallising of the medial coupling joint has taken place, dedoubling after that can only be a breaking up. Notwithstanding the great length of the axis in the series of elements now considered, therefore, after their medial joint has been metallised, their permanent existence in nature is secured. But, no doubt, by dedoubling previously, each atom of them must give birth to two atoms of some other brittle metal, whose atomic weight must be one-half of theirs, minus the medial or coupling joint. But on these we shall not touch.

In consequence of the great length of axis in this series of elements, they do not appear to be capable of assuming the æriform state as simple atoms. They appear to rise in isometrical yet differentiated molecules, consisting of dodecatoms within icosatoms, each occupying sixteen normal volumes, whence in the æriform state they have double the specific gravity which their atomic weights would lead us to expect.

Phosphorus, to which the greatest interest attaches, indicates the same structure in the solid after the distillate has been long preserved, and has recovered from the confusion of condensation. Thus,

$$\text{White Phosphorus, } \frac{P^{12+20}}{2AQ} = \frac{32 \times 155}{2 \times 1620} = 1{\cdot}53 \text{ Exp. } 1{\cdot}52.$$

And, by careful manipulation at a temperature such as to open up some molecules and set some single atoms free, it appears that the latter, in their impatience of individual existence, may be made to attach themselves symmetrically to the isometrical molecules again, giving a dodecatom over the icosatom, and so by increasing the weight, removing the molecule further from the attacks of oxygen. Thus,

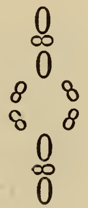
$$\text{Red Phosphorus, } \frac{P^{12+20+12}}{2AQ} = \frac{44 \times 155}{2 \times 1620} = 2{\cdot}1 \text{ Exp } 2{\cdot}14.$$

The elements now considered occur in nature, the heavier members mostly in union with sulphur, and the lighter members mostly or altogether in union with the lighter element, oxygen.

As to their natural combinations with sulphur, they appear to consist of the two elements both in molecules merely in juxtaposition, and so to be more of the nature of alloys than true sulphurides.

$$G = \frac{\overset{20}{S}}{AQ} + \frac{(Bi \text{ or } Sb \text{ or } As)^{1+12+1}}{2AQ}$$

With oxygen they form dodecatoms, the polar bodies being either the simple element or its suboxide, of which the latter is by itself most stable, and can indeed in certain cases, as in that of arsenic, be raised into the æriform state entire. Drawn and quartered, its formula is, of course, AsO_3. But, adopting a long compressed letter 0 to stand for the elements of this order, to indicate the great length of their axis, we may thus give its figurate formula—

Arsenious Acid, &c.,  $AsO.As\overset{10}{O}As.OAs = 4AsO_3$

$$\text{Its Vapours, } G = \frac{4AsO_3}{2Air} = 14 \text{ Exp. } 13{\cdot}85.$$

$$\text{Its Crystals, } G = \frac{4AsO_3}{\frac{1}{2}AQ} = 2{\cdot}5 \text{ Exp. } 2{\cdot}7.$$

$$\text{Its Mass, } G = \frac{(4AsO_3)^{12}}{4AQ} = 3{\cdot}74 \text{ Exp. } 3{\cdot}74.$$

When atoms of protoxide are removed from the poles, there remains arsenic acid ready for receiving other substances as polar bodies. These being as usual reckoned by chemists one instead of two, give the formula of this acid AsO_5 instead of $As\overset{10}{O}As$, that is, they give its nascent or immature form, instead of its culminate form.

Of all the elements of this order, the most interesting, as has been stated, is phosphorus. But, as has also been stated, its genesis in words is laborious. Only one case is simple. Thus, let there be an antimonic acid, in which the ten atoms constituting the body are barytic oxygens, and then, by simple rarefaction and development under the secular operation of specific heat, we obtain the equation—

$$\text{Antimonic,}\quad Sb\overset{10}{O}Sb = 4P\overset{10}{O}P = 8PO_5\quad \text{Phosphoric.}$$

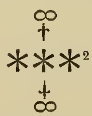
And by the breaking down of the dodecatom in various ways, fluorine, calcium, manganese, &c., are given to nature. But such inquiries belong to rational mineralogy, a science of the future.

Along with a mineral origin, phosphorus has also a meteoric origin. Thus, taking iron and nickel instead of oxygen for the construction of differentiated dodecatoms, along with phosphorus as polar elements, we obtain that ingredient in ærolites named phosphor-nickel-iron, or,

Schreibersite,	$PNi(\overset{10}{Fe})NiP$	giving per cent.	Fe 69·6 Ni14·9 P 15 .
	$NiPNi(\overset{10}{Fe})NiPNi$		Fe 60·6 Ni 26 . P 13·4 .

But if we ascend into a more serene region, a region in which there is nothing but hydrogen, but where synthetic action is very powerful, we also obtain phosphorus there, and that without anything but hydrogen along with it.

We have seen that hydrogen tends to form into hexatoms, which is the typical aërial molecule (Pl. I. fig. x.). We have seen also that these tend to group again into compound hexatoms. And, moreover, that when along with the hydrogen there are in the ambient medium single units of matter, these compound hexatoms tend to take these single units into union along with them, so that the hydrogen is fructified into aqueous matter (see p. 17), and, instead of the composite hexatom of hydrogen, there results—

A hexatom of Moisture,  $= OHa\overset{4}{q}HO = 6HO$.

But if, instead of H^6 as the nucleus of the hexatoms of hydrogen, there be only a single atom of H, and there be no matter in the ambient in the state of single units, then there results the aërial molecule of hydrogen, of which a figurate formula has been given in Pl. II. fig. VII., consisting of $5H^6 + H = 31H$. Now this structure, when consolidated to the utmost, yet so as to preserve as free as possible its hydrogen character, gives, though we cannot show it here,

$$31H = P \quad \text{Phosphorus.}$$

Suppose, then, that in the purely hydrogen region, where we now are, we have a composite hexatomic structure of hydrogen molecules analogous to the tetratomic $\overset{4}{H}\overset{4}{H}\overset{4}{H}$ or $\overset{4}{S}\overset{4}{S}\overset{4}{S}$, but in this case the polar members differentiated from the equaterial member by having only a single atom of H instead of a hexatom as the central body or molecule, we then obtain as the medial body a composite hexatom of hydrogen carrying a molecule of H_{31}, ultimately an atom of phosphorus on each pole—

$$6 \times 6\text{-hydride of Phosphorus, } P\overset{36}{H}P = 2.PH^{3\times6}.$$

Of this the skeleton is found in the terraqueous globe. A single atom of hydrogen takes the place of a hexatom. Thus from many animal substances when undergoing decomposition, and especially from that liquid which is the ultimate educt of animal nature, there arises a gas, whose composition chemists give as PH_3. This doubled as usual, in obedience to the law of symmetry, gives

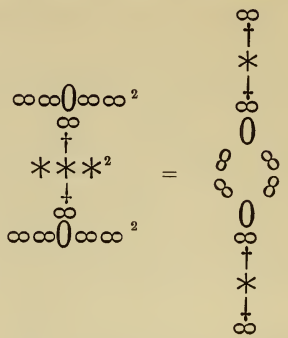
0
†
Phosphoretted Hydrogen, —+‡+— $P\overset{6}{H}P = 2PH_3$.
†
+
0

But to return to the original, namely, $P\overset{36}{H}P$, let now this combination come into a region, which is sown with matter in the state of single units, so that the composite hexatom of hydrogen may be dewed by them and transformed into moisture, and we obtain

0
∞
+
Hydrated Phosphorus, ✻✻✻² $P.OH\overset{4}{a}qHO.P = 2(P.3HO)$.
+
∞
0

Now in this region there will also be oxygen, and when oxygen is sufficiently abundant it will, as usual, in the case of forms with long axes, surround the equator of the atom of phosphorus with O_5, and thus we shall have as each of the polar bodies of our phosphaqueous combination PO_5, and as the equatorial body six atoms of moisture. But in this the poles are overloaded. Under the law of sphericity, this structure must tend to invert so as to construct a dodecatom at the centre, and to place the moisture as differentiating the poles. Thus we shall have—

Nascent Phosphoric Acid, . . .



Mature Phosphoric Acid, $= 2.PO_5.3HO$.

But it is to be considered that HO is very unstable, ever apt to lapse into aq. It is to be considered, at the same time, that on the atom of H in HO there are still four points for union, which are free or unoccupied. Where hydrogen is abundant, therefore, and HO in such a position that it cannot lapse into aq, there will gather in the H pole of HO four other atoms of H, and thereafter each of the three equatorial arms of the atoms of H added will tend to grow into 5H; or, to speak more generally, there will tend to gather in the pole of each atom of O ultimately twenty atoms of H. Now, these will tend secularly to be spherified and consolidated; for, as has been shown (p. 49), they are the very material for constituting a most exquisite metallic icosahedron (Pl. I. fig v. H_{20}). In fine, we get the secular equation—

$$20H,O \quad = \quad H_{20}O \quad = \quad CaO \quad \text{Lime};$$

and now, but not till now, have hydrogen and oxygen been combined in a ratio of perfect stability and repose. We shall, therefore, have ultimately (compared with what there has been supposed to be at first) the following analogy,

$$\text{Primal,} \quad HOHOHO,P\overset{10}{O}P,OHOHOH \quad = \quad 2(3HO.PO_5),$$

$$\text{Ultimate,} \quad CaOCaOCaO,P\overset{10}{O}P,OCaOCaOCa \quad = \quad 2(3CaO.PO_5).$$

Now by being doubled, this over-axial combination resolves itself into a very symmetrical and finely differentiated system of dodecahedra—

$$\text{Living Bone Earth} \quad P\overset{10}{O}P(\overset{12}{Ca}O)P\overset{10}{O}P \quad = \quad 4(3CaO.PO_5).$$

It may, however, be still more fully differentiated and so rendered more stable, namely, by the dedoublement of the acid dodecatom on its poles, and the opening up of the central basic dodecatom of lime into $CaO + \overset{10}{CaO} + CaO$, giving

$$\text{Bone Earth, } PO_5CaO.PO_5(\overset{10}{CaO})PO_5CaO.PO_5 \quad = \quad 4(3CaO.PO_5).$$

Now, it will be observed, that all these three combinations, when quartered as usual, give the chemical formula of bone-earth. And it might be shown that there is reason for inferring that this one or another of them exists in a bone, according to its use, size, or position, health or disease; for it is always to be remembered that great stability of molecular structure is incompatible with health and even with life. An element of bone-earth which will not accommodate itself to the changes in the living tissue in which it is embedded, and of which it ought to form an integral part, must be a cause of irritation like a thorn. An effort must be made to eject it which will not altogether fail, and a state of disease of the bone, with defect of bone-earth, must ensue.

To conclude; the position of bone (according to those views of its ultimate structure) in the economy of nature is extremely interesting, especially when viewed in relation to cerebral matter, which in the last analysis gives striking analogies. In the construction of both, Nature has put forth all her power of analysis along with synthesis, and produced tissues, which, in point of function, consistence, and duration, are indeed completely antithetic; but which, nevertheless, when viewed in their ultimate analysis, their genetic relationships and their place in nature strangely agree, bone being the more fully reduced of the two Thus, in the last analysis, bone-earth consists solely of hydrogen, boron, and carbon, the simplest and lightest of all the elements, together with oxygen, which must enter into every substance in the terraqueous globe, which is to be secure from the attack of this great corroder. And hence, by the way, during long epochs, in fossil bones for instance, a retrograde course of molecular action, calcium ($= H_{20}$) lapsing into fluorine, phosphorus dedoubling into silicon, and boron doubling into carbon.

As to cerebral matter, bone resembles it more in its axial part (the marrow) than in its peripheral part. In Part I. p. 153, I have given the possible construction of Liebreich's Protagon. But it is uncertain whether even this, notwithstanding all that chemist's gentle treatment of his material, be the true cerebral molecule. Chemistry, which first drives out of an organic morsel which is to be submitted to analysis an amount of the moisture that is in it which is quite uncertain, perhaps forbids our knowledge of the actual structure of the cerebral element as it exists in nature, the most marvellous product of combined molecular analysis as well as synthesis—muscle illustrating synthesis only.

CHAPTER XI.

THE ATMOSPHERE—NITRE, NITRIC ACID, ETC.

In what has preceded an account has been given of the organic elements, that is, those elements which are fit for maintaining vegetable and animal life, and which enter most largely into the structure of plants and animals.

Of the principal four, oxygen is that which is the great agitator and mover, and for its existence provision has been most securely made. As to the manner of its action, since its form is, as it happens, somewhat like that of a life-buoy, we may say that when oxygen is thrown in among the other organic elements, its atoms do for them what so many life-buoys thrown into the sea might do for human creatures in a shipwreck. As among the latter some individuals would seize the life-buoys sooner than others, and some would fit them better to their persons, so that the waves might be less able to part them; in short, as from the laying hold of the same life-buoys by different individuals,—some of them landsmen, and some of them sailors,—very varied combinations would both immediately and ultimately result, so with the atoms of oxygen when thrown in among the other organic elements. Almost all the action in organic nature which (from other causes) proceeds in such an orderly manner, and is productive of such beautiful developments, depends upon oxygen. There must, therefore, if there is to be life in our planet, be an unfailing supply of oxygen in the free or uncombined state—or if in the combined state, then so loosely combined, that the organic elements may be easily able to separate and appropriate it.

But how can there be a supply for long ages of such an element as this, which tends to unite and become parasitic on everything, and be imprisoned on all hands? How can it be retained for ages in the free state? At first sight the problem seems insoluble, unless the supply be infinite. Not so, however, when we reflect upon the grand law of molecular action,—unless, indeed, the supply of other molecules be infinite also. That law is the law of assimilation. When that law has been fulfilled, when the assimilation of separate molecules has been effected, there is no longer the same determination in them towards union. It is dissimilars only that unite from an impulse within. Hence, structures which are already mailed in oxygen will not attract to themselves and consume any more free oxygen, however much of it there may be in the ambient. They will rather repel it, and leave it free as they find it. Let the earth's crust, then, be fully oxidised, and we may have free oxygen everywhere notwithstanding. Now, this is the state of things which actually exists in the present epoch of our planetary existence. The earth's crust is fully oxidised, and free oxygen abounds everywhere; or if not just free everywhere, then so loosely engaged (in constituting moisture), that it can be easily obtained in the free state everywhere. An unit volume of the atmosphere, for instance, consists of free oxygen nearly to the extent of 21 per cent., and the air in water contains it, or tends to contain it, up to 33·3 per cent.

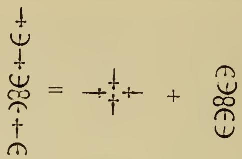
The Atmosphere.—The only question then is, Whence has this free oxygen been obtained? That it could not rise in the free state from a seething Plutonic or volcanic abyss we have already seen. In that case, we have seen that every atom of oxygen, every life-buoy, will be laid hold of by at least two, possibly by four of those zothic or lithhic bodies, which would be lost and merged in the abyss without it.

Confining our attention here to the latter case only, that in which four zothes lay hold of one atom of oxygen, and dropping our significant but grotesque figure, instead of an atom of free oxygen we obtain in the abyss an atom of oxygen crammed with metallic matter, viz.—

Potashium, 

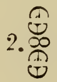
Now, if this escape from the seething abyss and attain in the nether vault or elsewhere the fully individualised or æriform state, certain changes under the law of symmetry and sphericity must take effect upon it.

In order that the axis of the atom of zothe (or lithhium), of which there are four in it, may be symmetrised, we have seen (p. 52) that an atom of hydrogen must be given out in the centre of the 5-fid region. Suppose this, then, to have been secularly accomplished in reference to all the four zhotes in our atom of potashium, we obtain an axial structure (see next page), consisting of an atom of oxygen in the middle, as the coupling-joint, and on each side two atoms of zote alternating with two of hydrogen. Now, such a structure is very loose, and the axis is by far too long. We may, therefore, expect that the four separate atoms of hydrogen will aggregate into a tetratom of hydrogen, while the terminal atoms of zote will turn round and apply themselves symmetrically to the other two. Thus will they greatly improve the structure. We shall thus obtain the equation—

Dilated Potashium,  Nascent common Air.

H_4 AzOAz

Now in this latter structure, though greatly improved, the axis is still too long; while, on the other hand, each of the coupled elements on both sides of the medial atom of oxygen (being atoms of Az, see p. 60), are eminently symmetrical and spherical, and every way well suited for individualised existence. This structure will, therefore, tend to break up into 2Az and O. But oxygen in the æriform state flies not in single, but in coupled atoms. Very soon, therefore, we shall have the equation—

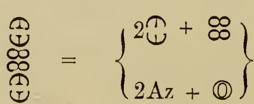
Nascent common Air,  = 4Az + ◎ Common Air.

That is, four volumes of azote and one of oxygen gas.

We should have obtained the same result had we set out with sodium instead of potassium; only that in this case, instead of one only, three atoms of sodium require to be taken in synthesis, and, along with common air, there is given to nature a residuum of lithia and silica.

Here, then, from the secular transformation of the first molecular structures of the abyss, we obtain azote (see Pl. II. fig. IX. Az) and oxygen in the same proportions (speaking generally) in which they exist in the atmosphere. And we see, at the same time, a sufficient reason for the great quantity of azote which exists in the aerial envelope of our planet, along with the free oxygen. However great, it is the smallest quantity which could save the oxygen and let it go in the free state.

Moreover, oxygen, having once established itself as oxygen gas, can enter the abyss again, and so far reconstruct the primal combination, while yet conserving for nature a double quantity of oxygen. Thus reconstructing the original azoto-oxygenic structure, with oxygen which had secured its existence as oxygen gas, we could only have the following equation—

Doubly Oxygenated Nascent Air,  Air in Water.

In which the quantity of oxygen in relation to the azote instead of being between 20 or 21 per cent. in volume, is between 33 and 34 per cent. And such appears to be the proper structure of the air which is given to fishes and the inhabitants of the deep for respiration.

As to the normal constitution of the entire atmosphere, however, that is a very crude conception which regards it as consisting of merely so much oxygen and so much azote mechanically mixed with certain other æriform particles accidentally introduced, though strangely found in very constant proportions. Our molecular philosophy leads us to regard the air when in a state of repose as we have regarded the ocean, that is, as a symmetrically-constructed medium, to which the terms aërial-crystalline might be applied, and possessing within itself the power to a certain extent of restoring its own composition when it has been anyhow disturbed or vitiated. And this the normal structure of the air, and not merely a certain mixture of pure azote and pure oxygen, we regard as that which is most favourable to health and life. To develope an unit of this mixed atmosphere here, and to show the genetic relationship of the various constituents, would lead us into too long details. Happily the student who has mastered all that has preceded may be able to do so himself. Here is its composition—

36 × {	12 × 12 × 12 × 12Az	76·223	Azote.
	12 × 12 × 12 × 3◎ + 12O	22·600	Oxygen gas and oxygen.
	12 × 12 × 3Aq	1·021	Aqueous vapour.
	12 × CO_2	0·069	Carbonic acid.
	AzH_3	0·005	Ammonia.

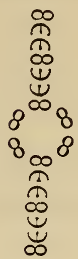
The atom of zote, when it has doubled and gained the æriform state as azote, may as to its place in nature be compared to hydrogen. It is when first given off in the position of a rejectamentum; but it is a rejectamentum so constructed, that when it falls into its right place it will be taken up into the course of nature again, and be found assisting beautifully in the grand cycle of molecular development, very near the beginning—in fact, only behind hydrogen itself. In the coupled state as azote, the zotic element has attained to such symmetry of structure and such sphericity, that when by itself, or mingled with others of its kind, it possesses, and cannot but possess, great repose. And hence infinite advantage to our world. If our atmosphere consisted in so great a measure of any other æriform but azote, it would have been the subject of such perpetual storms as would have destroyed all life. Still, every atom of azote consists of two parts, each of which by itself is the most active of all elements, and these two parts need only to be separated, or their relative positions changed, in order to the display of the most intense activity. Now, in constituting the atom of azote they merely touch each other. It may be inferred, therefore, that their separation will not be very difficult. If, instead of merely touching by their 5-fid summits, they had been locked into each other like the teeth in a rat-trap, or in the closed mouth of the shark, thus constituting a true unity and the most spherical form possible, their separation could not be looked for except under very peculiar circumstances. The properties of the resulting element in that case would be notably different from those of azote; and, in fact, we shall soon find that two zotes or lithiums thus locked together, and each locking up the metallicity of the other, constitute an atom of silicon. But from azote, as has been already shown, we may have the following series—

Zote. Azote. Antizote. Bizote.

Of these, we may expect all to have properties very different from those of azote, which to breathe is simply innocuous. And as antizote is symmetrical by itself, and may therefore exist in the fully individualised or æriform state, and as the law of differentiation, when it is not fully satisfied by the existence of the atmosphere in a normal state, must tend to develope antizote in the midst of the azote, we may possibly have in this antizote one of those morbific principles which sometimes certainly do exist in the air, but of which chemical analysis can find no trace, nor the actual chemistry of the day give any account. The action of poisons is indeed a perfect mystery; but I may here remark, that most probably an æriform atom of hydrocyanic acid may be regarded as an atom of antizote as polar matter, with an atom of anæsthetic (CHC) as body, (Ɔ0 + 0Ͼ = C_2HN æriform hydrocyanic acid?)

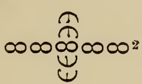
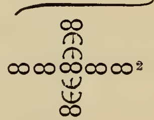
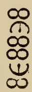
Oxides of Nitrogen.—With regard to the two last, which I have named bizote, in which the two atoms of zote are united thimblewise, what we are to expect here obviously is the same mode of activity as in the single atom, but of double intensity. Now, this combination (bizote) exists in potassium, as also in the most stable form of ammonia, which we have called biammonia. And of the latter very beautiful and finely explained by our theory are the transformations (oxygen being supplied in varying quantities) into nitric and nitrous acids, and nitric oxide. All of these in their most highly synthetic culmination or imago-forms are differentiated dodecatoms, the polar elements as usual being in nitric acid the bare doubled element, which we may designate as usual, with English chemists generally, by the letter N; in nitrous acid, the suboxide NON; and in nitric oxide, the sesquioxide ONONO, the body in all being ten atoms of oxygen. Thus, we obtain—

In Culmination Forms.

Nitric Acid.	Nitrous Acid.	Nitric Oxide.
		
$\overset{10}{\mathrm{N}}\mathrm{ON}$	$\mathrm{NON}\overset{10}{\mathrm{O}}\mathrm{NON}$	$\mathrm{ONONO}\overset{10}{\mathrm{O}}\mathrm{ONONO}$
$= 2NO_5$	$= 4NO_3$	$= 4NO_4$.

But these molecules still forming symmetrical structures, and maintaining the same ratios of nitrogen and oxygen, can dedouble and change to such an extent that many pages would not be sufficient to give their history and properties, physical and chemical.

In Minor Forms.

Nitric Acid.	Nitrous Acid.		Nitric Oxide.		
					
NO_5	$2NO_3$	NO_3	$2NO_4$	NO_4	$\frac{1}{2}NO_4$

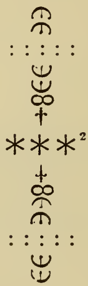
(Pl. II. fig. xv.)

This variability is also true of other combinations in which the same elements exist in combination, the oxygen being less in quantity. In fact, the modes of union of nitrogen and oxygen which elementary works on chemistry chose as the very type of simplicity and regularity, is one of the most varied and the most difficultly determined. It is all very well to say 1 : 1, or 1 : 2, or 1 : 3, &c., regarded as mere percentages reduced to their lowest terms. But to determine molecular structures is a very different thing. In reference to the combinations of nitrogen and oxygen, all that we shall here say is this, that they are as numerous as the phenomena which they display.

What our theory gives as most normal and symmetrical, and therefore most probably the product of nature, is nitric acid, commencing as nitrous acid in union with ammonia in the atmosphere, and in union with potassa and soda on the surface of the soil or in the strata. But even in reference to these nitrates, the mobility of the constituent nitric matter is so great, that differentiation seems to take place to a most unusual extent—to such an extent, indeed, as to vary the specific gravity, and to render very difficult the determination of the integrant molecule on which the specific gravity depends.

In extracting from these salts nitric acid for the use of the chemist and the arts, the entire distillate obtained from common nitre appears to possess a beautiful structure. Using dots in this case to represent atoms of oxygen instead of the figure 8, that distillate may be either—

or



$3HO.2NO_5$ $3H_2O.2N_2O_5$ (when $O = 16$).

That on the left hand is obviously the half-grown state of that on the right. Allowing it half an aqueous volume, and the other a whole aqueous volume, the sp. gr. of either is 1·5, which is precisely what has been found by the balance.

But this fine structure may be destroyed, and the moisture may be driven off till there remains only one atom of HO on each pole of the differentiated dodecatom. Thus—

Monohydrated Nitric Acid,  $2(NO_5HO)$.

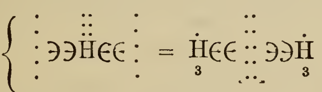
HON$\overset{10}{O}$NOH (Pl. II. fig. xvi.)

Now, supposing this to occupy $\frac{1}{4}$th of a normal volume, or to form into tetratoms (which the hydrogen poles must determine when the icosatom cannot be constructed) occupying one volume, the sp. gr. comes out 1·55, that given by the balance being from 1·55 to 1·52.

Nitric acid appears to be capable of attaining to the icosatom only when the whole surface of the molecule is loaded with moisture, giving 4 atoms to every atom of NO_5, and 9 to every atom of N_2O_5 (when $O=16$), the sp. gr. in the former case being 1·39, and in the latter 1·44, mean, 1·415, while experiment gives for the most stable nitric acid 1·42. But these are details which belong to the region of art, not of nature.

But it is the nitrates, not nitric acid, which possess the highest interest to the student of molecular nature, especially the possible genesis of nitrate of ammonia out of a primæval oxygen and common vapour, as also their every day genesis out of oxygen and ammonia, and this I may here notice because it illustrates generally the transformation by the action of oxygen of ammonia (biammonia) into nitric acid.

Given an atom of double ammonia in a region where oxygen abounds, then it appears that when the oxygen has attached itself to the ammonia as the law of symmetry determines, there will be 3◎ = 6O on the three naked hydrogen arms of the equator of the ammonia, and 5O probably forming a cup-shaped combination or hemisphere on each pole of the ammonia. Now, on any concussion of such a molecule by electricity or heat, a complete transformation is to be expected. The 6H of the body of the ammonia will unite with the 3◎ = 6O attached there, and generate 6aq = $2.\dot{H}_3$. At the same time the hemispherical oxygen poles will unite into a dodecatom which will be finely differentiated by the double zotes and the moisture on the poles. In a word, an atom of double ammonia, saturated with oxygen, must give—

Oxy-ammonia.  = $2(AzO_5 + 3HO)$ Terhydrated Nitric Acid.

Now we have seen that 2aq tends secularly to be transformed into am + H. Ultimately, therefore, instead of terhydrated nitric acid, we shall have—

Nitrate of Ammonia,  $2.(NO_5HO.NH_3)$,

the couple of stars standing for an atom of ammonia.

CHAPTER XII.

IRON AND COPPER.

The well-known properties of iron, when viewed in the light of our theory, enable us to construct its atom.

Thus, iron is so eminently magnetic that its magnetism may be rendered obvious to the senses, both by the visible motions and the arrests of motion which it produces. Now, this implies that its atom must be heteropolar in form, so that the rhythmical currents of force existing in its ætherial atmosphere may flow from pole to pole, and not, as is usual, between the poles and equator. For it is only when these currents flow from pole to pole that their force can be accumulated into a resultant, which may ultimately be powerful enough to produce sensible phenomena.

This eminent magnetism also implies that the molecular functioning of the atom of iron is intense, and, therefore, that its form departs largely from the spherical, which is the form of repose.

Further, iron is so universally diffused that the materials of which it is constructed must be present everywhere, in the upper regions, as well as in the earth itself; for quantities of iron often fall from the skies.

Further, it is a tenacious metal. One pole of the iron atom, there-ore, must be 5-partite.

But it is also heteropolar. The other pole, therefore, must be lens-shaped; for that is the only alternative to 5-partite in one and the same order of forms.

Further, the atomic weight of iron is 28 when $H = 1$. It is, therefore, precisely double of that of azote or bizote, silicon, and aluminium, all of which are very abundant, either in the air or in the earth, and all of which consist of two atoms of zote or lithium, coupled or consolidated into an unity one way or another.

Now, by doubling these abundant elements, and placing the four atoms of zote or lithium on the same axis in parallel positions, or thimblewise, so that each may be grasped and held fast by the five talons of the atom into which it is inserted, we obtain a structure which satisfies all these conditions, and which may, therefore, possibly represent iron. Therefore, possibly—

Tetrazote or Tetralithium, } =  = Fe = 140 = 28 when H = 1.

From its heteropolarity it could not possibly exist in single atoms in the æriform state; and, indeed, from its great length of axis, it is not easy to see how it could exist in the æriform state at all except in molecules. Its normal mode of existence must be molecular; and that its molecules are very various, as it is reduced from its ores, we may infer from its very variable specific gravity, viz., from 7·1 to 8·14. The differentiated dodecatoms, when grouped again into an isometrical composite dodecatom, give—

$$\text{Iron, G} = \frac{(\text{Fe}(\overset{12}{\text{Fe}})\text{Fe})^{12}}{2\text{AQ}} = 7{\cdot}25.$$

And if the high magnetic character of the single atoms should cause them to settle upon the primary dodecatom again and again symmetrically, we should obtain—

$$\text{Iron, G} \ldots \frac{\text{Fe}^{12+20+12}}{\frac{1}{2}\text{AQ}} = 7{\cdot}6.$$

But many other molecular states are possible, and as they must differ from each other in tenacity and mechanical value, there is a fine field for inquiry in the metallurgy of iron.

But not to enter on this subject here, let us now inquire into the other elements, both metallic and metalloidal, by which such a substance may be expected to be accompanied.

Nickel.—In the ferric element as conceived above, all the four constituent lithiums are fully reduced. No one of them remains in the primal state of ᴗ = ᴗ̇ with + above. But the stability of the fourfold combination would be secured though the process of reduction had taken effect only upon two out of the four. An atom of crude zhote ᴗ, when free, must indeed soon either disolve into 5 ♄, or be transformed into S or O. But when grasped in the pole of an atom of reduced zote ᴗ, which is wholly undecomposable, an atom of ᴗ must remain undecomposable also. Along with iron, therefore, when it has been generated hurriedly, so that there has not been time for the reduction of all the four atoms of lithium constituting it, or when through any cause that reduction has been arrested, there will result another metal highly magnetic like iron, and many ways resembling iron, but its atomic weight heavier by two atoms of hydrogen. Now, this inference is responded to by—

Hurried Iron = ЄЄЄЄ = Nickel = 150, *i.e.*, 30 when H = 1.

Nor is this the only magnetic metal which offers itself in this connection. It might be shown that our molecular morphology gives us in connection with iron (Ferric acid)—a beautiful theory of the genesis of chromium (hydrate of the oxide of chromium), &c.; while the atom of baric iron, by partial reduction, gives us cobalt and its baric associates. But these metals are rare and of comparatively little interest in mineral geology. We therefore pass them over without more words.

But let us ask the question, in this part of our construction, whether we obtain any insight into the structure of the atom of another metal which is scarcely less generally diffused in nature than iron itself, which is usually associated with iron, or rather which appears to take its place as the iron disappears, and which in many of its physical and chemical characters seems curiously contrasted with iron. I allude to—

Copper.—Does our theory give us any insight into the genesis or structure of the atom of copper? To this it is to be answered, that as we have found the alkali-metals dedoubling into those of the alkaline-earth metals, there is obviously now occasion for adding another to the series. The sesquioxide of iron differs, indeed, from the sesquioxides of lithium, and of bilithium, in being decomposable by human art. And this difference we can easily understand on account of the extreme length of the axis in the atom of sesquioxide of iron. But, for the same reason, the latter ought to be prone to dedouble by the opening up of the medial atom of oxygen. Now, this done, we shall obtain a new metallic species. Its atomic weight must be that of $Fe + \frac{1}{2}O = 28 + \frac{8}{2} = 32$ when H = 1. But it is no longer heteropolar. It will, therefore, be no longer magnetic like iron. Rather, in its relations to magnetism it must be the reverse of iron. Moreover, its atoms under the law of redintegration will tend to go in couples; and when given to nature in union with oxygen it must usually occur as a protoxide. In all these respects it represents copper, being the last of the following series—

Li_2O_3.........O϶OЄO	=	$\acute{N}aO_2$	=	2.MgO	Magnesia.
Li_4O_3......O϶϶OЄЄO	=	$\acute{K}O_2$	=	2.CaO	Lime.
Li_8O_3....O϶϶϶϶OЄЄЄЄO	=	$FfeO_{2+1}$	=	2.CuO	Copper oxide.

It is in connection with copper pyrites, however, that the evidence that such is the nature and genesis of copper (if that of iron be granted) becomes altogether convincing. This mineral is the source whence most of the copper of commerce is derived, and it is well known to possess the singular formula of—

$$\text{FeCuS} = \text{Fe}\overset{4}{\text{S}}\text{Cu},$$

that is, an atom of sulphur carrying one of iron on one pole, and one of copper on the other. Now, let us take a normal or symmetrical sulphuride of iron, $\text{Fe}\overset{4}{\text{S}}\text{Fe}$, and form it into a dodecatom; then let that dodecatom be encrusted by oxygen; and then let the set of $\text{Fe}\overset{4}{\text{S}}\text{Fe}$ elements be overlaid, so as to give a double walled molecule, each member of that molecule consisting of two atoms of symmetrical sulphuride of iron united by an atom of O as the coupling-joint; and then, in consequence of the great length of axis, let dedoublement take place by the opening up of the medial atom of O, and we obtain—

$$\left.\begin{array}{c}\text{Oxysulphuride}\\ \text{of Iron,}\end{array}\right\}\left\{\begin{array}{l}\text{Fe}\overset{4}{\text{S}}\text{FeOFe}\overset{4}{\text{S}}\text{Fe} = \text{Fe}\overset{4}{\text{S}}\text{Fe}\overset{e}{\text{B}},\overset{e}{\text{B}}\text{Fe}\overset{4}{\text{S}}\text{Fe}\\ \quad = \text{Fe}\overset{4}{\text{S}}\text{Cu},\text{Cu}\overset{4}{\text{S}}\text{Fe} = 2\text{Fe}\overset{4}{\text{S}}\text{Cu}\end{array}\right\}\begin{array}{l}\text{Copper}\\ \text{Pyrites.}\end{array}$$

Thus our theory of the nature of iron receives every support from looking to the substances with which iron occurs most intimately associated in nature. It is supported no less by looking to the substances which constantly make their appearance along with it in the arts. These are principally carbon, silicon, sulphur, and phosphorus. And so constantly are these substances present, more or less, whenever there is iron, that there is no reason to suppose that there ever was any considerable quantity of iron without them.

Cast Iron.—Now, as to carbon, though doubtless it has ample opportunity of being introduced from the fuel commonly used in iron smelting, yet our theory leads us to expect that it would make its appearance though the iron were reduced from a perfectly pure oxide or sulphuride, by an oxyhydrogen flame or the voltaic arc. Thus, suppose the liquid metal to consist of dodecatomic molecules of iron, they must tend to become differentiated. Now of this one of the purest modes, if the metal is to remain in the liquid state, is the demetallisation of the terminals of one of the six axes of the dodecahedron, as usual, by the gathering up of the five units which constitute these terminals into an atom of hydrogen. But by such a step the terminals of the axis are transformed from $\ni$ to HC, and this, supposing none of the carbons of the hydro-carbon to escape, implies the development in the iron of 3·6 per cent. of carbon. Such a metal must also, when it has concreted, be brittle like silicium, manganese, chromium, antimony, bismuth, &c., and other masses consisting of molecules with lens-shaped poles.

Now the percentage of carbon, which we have deduced in this way, may be taken as the normal average of what is found in iron that has been liquid in quantities, and has concreted. The concrete is also brittle, and is known as cast iron.

According to our theory, it is also to be expected that it will be impossible wholly to purge any considerable mass of iron from silicon. Thus two atoms or molecules of iron, when the 5-partite regions of their surfaces are pressed together, may lock into each other. And if they should lock so intimately that the two zotes or lithiums thus locked will hold together rather than to the other zotes to which they are attached in the atom of iron, an atom of separable silicon is generated, for ϵ϶ when locked together give ⊖ = Si.

As to sulphur, since S and ʊ are alternate forms of the same element 5Ḥ, and an atom of sulphur $\overset{4}{S}$ is the numerical equivalent of crude iron ϶϶϶϶, sulphur also may be always expected in iron, the quantity varying according to the mode of development.

And no less may phosphorus be expected. Thus, wherever ʊ is undergoing reduction to ω, abundance of nascent hydrogen must be set free, and ʊ = BB, that is, boron in coupled atoms. Now, an atom of phosphorus, when completely decomposed, consists of BBBB + (3 × 5H). In iron, therefore, there is abundant material for the genesis of phosphorus.

But it is not in the smelting or puddling furnace that we can study with advantage the genesis of phosphorus, this most composite and yet most elemental of material substances. This study may best be conducted in the sky. This subject, however, I shall not resume.

As to meteoric iron, it follows from our theory, that it may possibly be generated from the stormy transformation both of nitric acid and biammonia, and especially from their stormy union. Also, by any cause which may invert the positions of the two atoms in azote, so as to give ϶϶ instead of ϵ϶. The plunge of an atom of ϵϵ$\overset{10}{O}$϶϶ into one of ϶϶$\overset{6}{H}$ϵϵ, that is, of bizotic (nitric) acid into biammonia (laboratory ammonia), immediately generates ϶϶϶϶, which, in the requisite conditions, may be consolidated into Fe. Moreover, atoms of ϶϶ must immediately aggregate into $(϶϶)^{12}$, and these receiving the same again as an incrustation, must become,

$$\text{Meteoric Iron,} \qquad (϶϶϶϶)^{12} \quad = \quad \overset{12}{Fe}.$$

Hence also chromium, silicon, carbon, &c., in the aerolite.

But while our theory thus admits of the meteorite being formed in the bosom of the storm, it does not deny that meteorites may also come from the planetary spaces. On the contrary, it rather assigns a cosmical origin to all such visitants of our planet.

And here we may remark, that the function which we thus conceive that ammonia, $\ni\ni\overset{6}{H}\in\in$, may perform in the higher atmosphere, may be performed by potassium $\ni\dot{\ni}O\dot{\in}\dot{\in}$ at the earth's surface. The meteoric masses, bits, and dust, which fall to the earth's surface may be represented by ochre and bog iron-ore, which make their appearance in such quantities on the earth's surface, in those too dark and cold climates where a successful nitrification can scarcely be accomplished.

Iron Oxides.—The atom of iron, as might be expected from the length of its axis and its heteropolarity, perseveres with great determination in a molecular state.

The simple dodecatom coated with oxygen, one atom on each of its twelve members, constitutes the

$$\text{Protoxide of Iron,} \quad (\dot{Fe})^{12} \doteqdot FeO.$$

But in this wholly undifferentiated and free state it has not yet been obtained by the chemist.

The blacksmith, however, notably disengages it with the simplest possible differentiation, viz., now an atom of O, now one of Ⓞ on each pole, the first giving 25 and the second 27·6 per cent. of oxygen.

$$\text{Scale Oxide,} \quad . \quad . \quad O(\overset{12}{\dot{Fe}})O \doteqdot Fe_6O_7$$
$$\text{Magn. Scale Oxide,} \quad Ⓞ(Fe)^{12}Ⓞ \doteqdot Fe_6O_8 = 2.Fe_3O_4.$$

The latter proportion of iron and oxygen is also abundant in nature. But it appears to be distributed in molecules consisting of OFeOFeOFeO, for it is magnetic. Now, in such combination we see a ground for free magnetism, since three atoms of iron on the same axis, however they may be arranged, cannot neutralise each other's magnetism.

It is, however, the relation between the protoxide and the peroxide of iron that possesses the highest interest,—an interest which is not merely physical and chemical, but physiological also.

Iron oxide appears to be developed in nature simply by the differentiation of the molecule of the protoxide by the addition of other atoms of protoxide to the poles, till these poles become so long that each fixes five atoms of oxygen as an equatorial expansion for itself. We thus obtain—

$$\left.\begin{matrix}\text{Vital Peroxide}\\ \text{of Iron,}\end{matrix}\right\} OFeOFe\vdots\dot{O}\vdots FeOFe\left(\overset{12}{\dot{F}}\right)FeOFe\vdots\dot{O}\vdots FeOFeO = Fe_{20}O_{30} \doteqdot Fe_2O_3$$

But now, under the law of unification and sphericity, the 5 atoms of O surrounding each pole must tend to move towards the body, thus mailing it in deutoxide, and giving—

Matured Peroxide of Iron, $\Big\}$ $OFeOFeOFeOFe\big(\vdots\dot{\underset{12}{Fe}}\vdots\big)FeOFeOFeOFeO = Fe_{20}O_{30}$

But now the atoms of protoxide on the poles must be very liable to depart spontaneously, or to be carried off by any acid. Now when they are carried off, then the 10 atoms of oxygen on the body which constitute a deutoxide there must be set free ! Thus peroxide of iron must be a beautiful apparatus for supplying oxygen for the blood or the living tissue, in ten atoms at a time, that is, precisely in the number of atoms simultaneously which are generally wanted simultaneously, for the construction of dodecatoms or definite molecules.

That the peroxide as it occurs in nature has something of this structure appears from its specific gravity. Thus—

$$\text{Specular Iron, G} = \frac{\dot{\underset{4}{Fe}}\big(\vdots\dot{\underset{12}{Fe}}\vdots\big)\dot{\underset{4}{Fe}}}{\frac{1}{2}AQ} = Fe_{20}O_{30} = 4{\cdot}94. \quad \text{Exp. } 5.$$

If it were an elemental sesquioxide OFeOFeO, its molecule must be a dodecatom, either isometrical or differentiated; but neither of these will give the experimental specific gravity. By its partitionment the oxide now conceived can give every oxide.

(1.) Each successive joint, and the whole when the ten supernumerary atoms of oxygen are removed, gives protoxide.

(2.) The division of the polar parts of the axis at the middle, as also the remainder, gives $OFeOFeO = Fe_2O_3$, the sesquioxide, which may surely often exist as a peroxide of iron $(OFeOFeO)^{1+12+1}$.

(3.) The polar parts, when removed at a joint nearer the centre, give—

$$\text{Magnetic Oxide, } \frac{(OFeOFeOFeO)^{1+12+1}}{AQ} = 5. \ \text{Exp. } 4{\cdot}9\ldots5{\cdot}2.$$

Hydrated Peroxide.—The simple sesquioxide appears to exist in this form when hydrated as it is in

$$\text{Brown Hæmatite, } \frac{(\underset{2}{\dddot{Fe}}.OHaqHO.\underset{2}{\dddot{Fe}})}{2AQ} = 3{\cdot}44. \ \text{Exp. } 3{\cdot}4,$$

rising when water is lost to 3·95.

The Sulphurides of Iron.—While the molecule of iron, $\overset{12}{Fe}$, tends to be encrusted with oxygen, as we have seen, and by its differentiation to give rise to a variety of oxides, it must tend no less, nay more, to be encrusted by sulphur, which is more truly an equivalent to iron than oxygen, both as to weight and difference of form. Hence, as a most generally diffused substance, we may expect to find a simple sulphuride of iron.

Common Pyrites. $(\overset{4}{S}Fe)^{12} \doteqdot FeS$ Auct.—And since sulphur is transparently yellow, while iron is of white metallic lustre, and the sulphur is on the surface in this molecule, with the iron as a silvering behind or beneath, we may fairly expect this sulphuride to be golden in appearance.

Marcasite. $(Fe\overset{4}{S})^{20} \doteqdot FeS$ Auct.—But this yellow sulphuride molecule may be subject to inversion, that is, a molecule of sulphur, $\overset{20}{\underset{4}{S}}$, may be encrusted by iron, as well as a molecule of iron by sulphur; and in this case, the surface of the molecule being metallic white, we may expect the pyrites to have rather a silvery than a golden appearance; and since the molecule is no longer dodecatomic, but icosatomic, we may expect the crystalline form also to be different. The differentiated dodecatom gives $G = 5{\cdot}06$, and the icosatom gives $G = 4{\cdot}2$, two of the former and one of the latter being supposed to occupy an aqueous volume. Experiment gives G from 4 to 5, and indicates great internal differentiation.

Magnetic Pyrites.—If sulphur be tending to the state of vapour, $\overset{4}{S}\overset{4}{S}\overset{4}{S}$, but retain on both poles an atom of iron, as also one on each of the three sulphic arms of the equator, we obtain a finely constructed pyritic element composed of $\mathbb{S}_3F_5$, giving 40·79 per cent. of sulphur. In consequence of the distribution of the iron on the equator, it may also be expected to be magnetic. But the sulphurides and sulphides of iron, like the oxides, may possibly be almost endless.

Green Vitriol.—In common pyrites the sulphur being peripheral, and therefore exposed to both the moisture and the oxygen which are almost all-pervading in the terraqueous globe, and having such an affinity for both, it is to be expected that pyrites in the course of nature will undergo decomposition. Its prospects of permanence would, indeed, be but little if at all better, if the iron were peripheral, as it appears to be in other species; for iron in single atoms is as liable as sulphur to the attacks of moisture and oxygen. Let us take for illustration the simplest soluble or insulable particle of pyrites, viz.—

Com. Pyrites, $\overset{4}{S}FeFe\overset{4}{S}$ The dodecatom being broken up.

Suppose now one atom of $\overset{4}{S}$ alone to be attacked by moisture—

$$\left.\begin{matrix}\text{Hydrous}\\ \text{Pyrites,}\end{matrix}\right\} aq\overset{4}{S}aqFeFe\overset{4}{S} = O.H\overset{4}{S}H.OFeFe\overset{4}{S} = \left\{\begin{matrix}H\overset{4}{S}H\\ \\ OFeFeO\end{matrix}\right\}\text{Sulphur.}$$

That is, sulphuretted hydrogen, iron protoxide, and sulphur. Now, the first will go off, the protoxide will tend to grow into peroxide, and this, forming in the presence of moisture, will give hydrated peroxide of iron, or brown hæmatite, mixed with particles of sulphur. Such will be a product of the imperfect decomposition of the pyrites.

But if oxygen be fully present, as well as moisture, then, instead of particles of sulphur, we may expect a sulphurate of moisture, tending to dedouble into two atoms of glacial oil of vitriol, viz.—

$$\left.\begin{array}{l}\text{Hydrous and Oxy-}\\ \text{genated Sulphur,}\end{array}\right\} \text{OHaq}\overset{\vdots\vdots}{\underset{4}{\text{S}}}\text{aqHO} = 2(\text{aq}\overset{\vdots}{\text{S}}\text{aqS}) \left\{\begin{array}{l}\text{2 atoms Glacial}\\ \text{Oil of Vitriol.}\end{array}\right.$$

Now, awaiting for union with these two atoms of bihydrated sulphic acid there is OFeFeO—not, however, in this anhydrous state, but as a dodecatom, the body being $(\overset{10}{\text{HO}})$, giving $\text{OFe}(\overset{10}{\text{HO}})\text{FeO} = 2\text{FeO.5HO}$, a normal hydrate (which in many analogous substances has been insulated in the laboratory, such as $\text{OK}(\overset{10}{\text{HO}})\text{KO} = 2(\text{KO.5HO})$ the crystalline hydrate of potass). We thus obtain—

$$\left.\begin{array}{l}\text{Nascent}\\ \text{Green Vitriol,}\end{array}\right\} \text{aq}\overset{\vdots}{\text{S}}\text{aqS}.\dot{\text{F}}\text{e}(\overset{10}{\text{HO}})\dot{\text{F}}\text{e}.\text{S}\overset{\vdots}{\text{a}}\text{qSaq} = 2.(\text{FeO.SO}_3 + 7\text{HO}).$$

But of such a molecule the axis is long compared with the equatorial diameter. We have, therefore, as in the case of Epsom salt, to suppose that these single elements of vitriol aggregate into the molecule proper to them, that is, into an aquaform molecule, consisting of 36 elements and occupying an ice volume. This, therefore, we regard as—

$$\left.\begin{array}{l}\text{Matured}\\ \text{Green Vitriol,}\end{array}\right\} \frac{(\text{aq}\overset{\vdots}{\text{S}}\text{aqS}.\dot{\text{F}}\text{e}(\overset{10}{\text{HO}})\dot{\text{F}}\text{e}.\text{S}\overset{\vdots}{\text{a}}\text{qSaq})^{36}}{\text{Ice vol.}} = 1{\cdot}93.\text{Exp. } 1{\cdot}8 \ldots 1{\cdot}9.$$

It is not to be inferred, however, that anhydrous sulphates, or even all hydrous sulphates, possess this structure. In that case six atoms of HO, at least, would be requisite in the common chemical formula for every atom of oxide. But some, as for instance Blue Vitriol, have only 5HO. In their structure the latter are true sulphurates (see p. 38). Their molecules being dodecatomic occupy half an ice volume.

$$\left.\begin{array}{l}\text{Blue}\\ \text{Vitriol,}\end{array}\right\} \frac{(\text{Cu}\overset{\cdot\vdots\vdots\cdot}{\underset{4}{\text{S}}}\text{Cu}(\overset{10}{\text{H}}\text{Oaq})\text{Cu}\overset{\cdot\vdots\vdots\cdot}{\underset{4}{\text{S}}}\text{Cu})^{12}}{\tfrac{1}{2}\text{ Ice vol.}} \div \text{CuOSO}_3.5\text{HO} \ldots \text{G} = 2{\cdot}3. \text{ Exp. } 2{\cdot}2.$$

Our theory presents the single atom of iron as the most powerful of all the organic elements, its power arising partly from its heteropolarity, partly from its length of axis. But that old names cannot be changed, our systematic name for it, TETROZOTE, therefore, would be as descriptive of its functioning as of its structure.

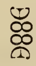
CHAPTER XIII.

ALUMINUM AND SILICON.

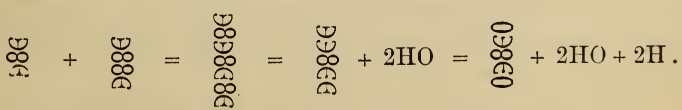
In what has preceded we have found that the principal chemical elements—that is, those molecules whose structure is so stable that nature transforms them only secularly, or by operating on them during long epochs, and the chemist cannot as yet transform them at all—are generated by the mutual action of oxygen (Pl. I. fig. xiii.) and lithhium or zhote (Pl. II. fig. i.), two isobaric elements consisting of the same material, namely, of 5 bitetrads, usually represented by us thus—

Oxygen,  ....  Lithhium or Zhote.

We thus obtained for the very first products of the primæval abyss as the quantity of oxygen was increasing, and was acting both in single and in coupled atoms—

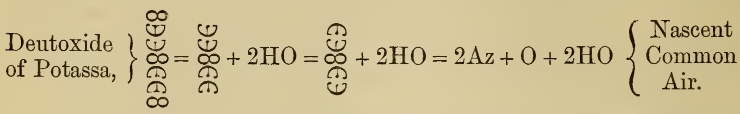
Suboxide of Lithhium = Sodhium, }  ....  } Oxide of Lithhium = 2 atoms of Lithhia.

Now, these two being dissimilar, will tend to unite, as dissimilars ever tend to do, and that symmetrically. Moreover, in order to this, the latter will dedouble, one of its two members placing itself on each of the two poles of the former, so that the whole shall have one axis. This structure effected, the symmetrising of the axis in the atoms of lithhium will commence, that is, they will be reduced from lithhium to lithium, by the emission of an atom of hydrogen by each from its non-symmetrical five-fid pole. And this will take place first where there is an atom of oxygen to receive the atom of hydrogen just given out. Thus we shall have—



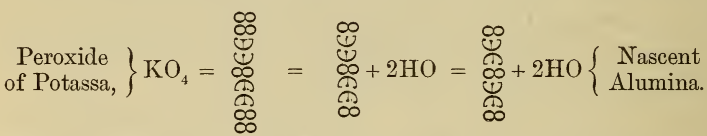
Sodhium. 2. Lithhia. Lithi-sodhium. Potassium. Chlorine, &c.

But if there be a limited supply of free oxygen, the reduction of the metallic element to the degraded form of chlorine may be prevented. Thus, let a single atom of oxygen be given to each of the poles of the atom of potassium. The transformation will then be, and will tend to give—



Thus, when oxygen is supplied in limited quantity to the abyssal alkaline matter, the transformation issues in the genesis of azote, with the liberation of oxygen gas in the free state, in the proportions of 4Az + © along with moisture,—in a word, in the genesis of the atmosphere.

Alumina.—But when oxygen gas, or at any rate oxygen in coupled atoms, exists already in the abyss, so that there may be a coupled atom of oxygen on each pole of the atom of potassium, giving the peroxide KO_4, another result may be expected. In this case, after the symmetrising of all the elements of lithium in the structure, accompanied by the genesis of as many atoms of moisture, these lithiums, by placing themselves in symmetrical positions in relation to each other, may be able to prevent degradation, and to preserve the entire structure as an unity.



Now, on inspecting the last formula, it may be seen that it may also have a much simpler genesis. It may result from the simplest elements, provided they be old enough to have been secularly symmetrised, and placed in their ultimate positions in relation to each other. Thus, referring to the first substances noticed in this chapter (sodhium and lithhia), it is to be considered that the secular operation of nature upon them is not completed when, by the emission of hydrogen, they have been reduced to sodium and lithium ; but under the secular operation of their specific heat, which ever tends to render all molecular structures as cellular as possible, the atoms of lithium in both must invert their positions in reference to the atoms of oxygen with which they are united, and instead of nestling parasitically in the concave poles of the oxygen, they must rather rest upon their edges, merely holding them fast by their five toes. Thus we obtain—

Now, the last form opening and applying its two halves to the poles of its neighbour as before, and for the same reason, there results the same structure as I have named, nascent alumina—nascent, because though a late product of nature compared with many other elements, it is obviously only an element in a nascent state; for its axis, especially if it carry on its poles the atoms of HO which have been given out by it, is so long, that there must exist under the law of sphericity a great force tending to shorten that axis. Now, this cannot be accomplished in reference to the atoms of oxygen which enter into the axis; for the axis of the atom of oxygen being zero is as short as possible already. But it may be effected in the case of the pair of coupled lithiums, which merely touch each other by their poles. By an inadequate compressing force, each may obviously penetrate the other, so that both shall have a common axis. By this the length of the axis of each will be reduced to one-half, and there will be given to nature a new metal (see Pl. II. fig. XVII. Al), nearly isamorphous with magnesium, and of the same order of form as the alkaline-earth and alkali metals generally, and therefore tenacious and ductile like them, yet with more solidity. But it must occur in nature as a sesquioxide, and possess an atomic weight, which, when the atom has lost none of its units during the ordeal of compression and the long previous existence to which it has been subjected, must be $2 \times 35 = 70$, *i.e.* 14 when $H = 1$. These characteristics mark our new metal as representing aluminum. Supposing this element during its genesis to have lost two out of the seventy of its units of weight (some such loss being indicated by its atomic weight as experimentally determined), and that, like silver and gold, and other metals which oxygen does not attack at ordinary temperatures (many of which have, in fact, aluminum poles), it consists of a dodecatom with an icosatom overlying, we obtain—

$$\text{Aluminum,} \quad \frac{(\text{Al})^{12+20}}{\frac{1}{2}\text{AQ}} = \frac{32 \times 68}{\frac{1}{2} \times 1620} = 2{\cdot}68. \text{ Exp. } 2{\cdot}67.$$

It so rarely exists apart from silica, that crystals of pure alumina are rare (sapphire, ruby, &c.) Their specific gravity is found to be 4·08. Now, the simple dodecatom gives 3·82, and the differentiated dodecatom, 4·46—mean, 4·14.

The relation in nature between the two great mineral constituents, silica and alumina, is of the greatest interest. Alumina, which scarcely appears in ærolites at all, makes its first appearance on the crust of the earth as a differentiating element upon the poles of a dodecatom, the body of which is silica. But, ultimately, these two relative positions are reversed—alumina forms the body, and silica, &c., the poles! And, last of all, the body is no longer a dodecatom, but only a single atom of alumina, with one of silica on each pole. When, to this structure, an atom of moisture is fixed on each pole, the mineral world gives way, and is almost prepared for the reception of the vegetable world. Thus, to enable the eye still to mark the symmetry, and taking a dot for an atom of oxygen, we have—

$$\text{Pure Clay,}\quad \dot{\mathrm{H}}\ddot{\mathrm{Si}}\underset{2}{\dddot{\mathrm{Al}}}\ddot{\mathrm{Si}}\dot{\mathrm{H}} = Al_2O_3 . 2SiO_2 + 2HO\ (\text{Auct.})$$

By securing a terminal atom of aq on each pole, so as to give an opportunity of constructing the aqueous molecule instead of the icosatomic, this combination may, however, still claim a place in the mineral kingdom—

$$\text{Halloysite,}\quad \frac{(\mathrm{aq}\dot{\mathrm{H}}\ddot{\mathrm{Si}}\underset{2}{\dddot{\mathrm{Al}}}\ddot{\mathrm{Si}}\dot{\mathrm{H}}\mathrm{aq})^{36}}{\text{Ice vol.}} = \frac{36 \times 740}{16 \times 1620} = 2{\cdot}2.\ \text{Exp.}\ 2{\cdot}12.$$

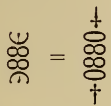
And here an interesting field in rational mineralogy presents itself in studying the development of barytic aluminum associated with baric and barytic oxygen, giving in intermediate stages fluorine and sodium, as well as aluminum (chiolite, cryolite), and, ultimately, phosphate (wavellite). But such investigations we must pass over in this hurried sketch, remarking only that the very interesting mineral cryolite has for its molecule the fully differentiated dodecatom of the type $\mathrm{XOX}\overset{10}{\mathrm{O}}\mathrm{XOX}$, in which baric oxygen or fluorine plays the part in reference to sodium and aluminum which is usually played by common oxygen. Adopting a larger dot to stand for fluorine, we thus obtain—

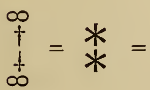
$$\text{Cryolite,}\quad \frac{(\underset{2}{\dddot{\mathrm{Al}}}\dot{\mathrm{Na}}\underset{2}{\dddot{\mathrm{Al}}}\underset{10}{(\dot{\mathrm{Na}})}\underset{2}{\dddot{\mathrm{Al}}}\dot{\mathrm{Na}}\underset{2}{\dddot{\mathrm{Al}}})^{12}}{\frac{1}{2}\ \text{Ice vol.}} = 4(3NaF.Al_2F_3) = 3.\ \text{Exp.}\ 2{\cdot}96.$$

Silica.—We hasten to notice a product of the material system which, had we viewed it in reference to its abundance in our planet, would have been entitled to a much earlier consideration; but, as its position in the economy of nature appears to be rather that of an *unavoidable* substance, than one which goes directly to advance the great end of creation, I have reserved it for the last. I allude to silica, the material of sand, quartz, sandstone, and more or less of almost every rock. Moreover, while silica owes its existence to its being unavoidable, if molecular synthesis is to proceed according to law, it is, at the same time, so stable and so untransformable compared with most other elements, that it might also be regarded as *residuary* or *abortive*. The normal course of development may be thus conceived. There is given very early in the abyss the lithic alkali in coupled atoms (see p. 57), and this, when protected from the further attacks of oxygen, by carrying an atom of oxygen on each pole, gives—

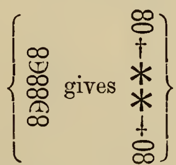
1.  Now, this by symmetrising the axes of the lithiums, by the emission of an atom of hydrogen from each, becomes,

2.  which is hydrate of lithia $= 2(LiO.HO)$. Now this, omitting the moisture on the poles, *i.e.*, 2HO, gives,

3.  that is, 2HCO, a couple of saccharines, the dodecatom being $C_{12}H_{12}O_{12}$, *i.e.*, sugar. The moisture gives—

4.  = 2aq. Now it has been shown (see p. 96) that 2aq gives am + H, *i.e.*, an atom of ammonia + H.

Hence, using the two stars still to represent an atom of aquæform ammonia, we obtain, by synthesis, the equation—

The simplest abyssal alkali saturated with oxygen,  Sugar of gelatine with single instead of double atoms of CO on its poles.

$2(LiO_2HO)$ $C_2H_5NO_2$

Thus does molecular action from the very first press on towards the construction of molecules which shall be fit for the purposes of animal life. The postponement of the study of organic chemistry till after the chemistry of all the constituents of the crust of the earth has been discussed, is quite an invention of the philosophical order of inquiry, is a profound mistake, and has, down to this day, prevented all insight into the grounds of the healing art. Matter, which is a geometrical deposit by life, aims at the recovery of life directly. From the very first there is no individualised combination, if it be the work of nature and not of art, which may not be justly regarded as organic.

But, during this ascent from the chaos of the seething abyss into the realm of individualised and regulated life, it is only to be expected that material elements, moving blindly under an inexorable law, which provides for perfection of form only, and takes no special account of the exi gencies of sensibility, shall often step aside, and take short cuts towards that perfection of form, and thus may give rise to molecules, which, in consequence of their stability or deadness, may be useless for life, being incapable of moving in obedience to the urgency of feeling, or the commands of volition.

As soon, for instance, as there is a medium or neighbourhood consisting of structures such as that marked No. 3 in the preceding page, we may expect the following equation—

Poles metallic,  =  Poles non-metallic.

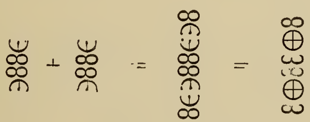
The law of differentiation will tend to effect the inversion, as represented on the right hand, of half the number of molecules in the medium, in the act of which the two lithiums may be expected to clap together with such force as to lock into each other, or, if not at the moment of genesis, then afterwards under adequate pressure.

Silicon.—We thus obtain as a body, between two atoms of oxygen as its poles, an element of the most exquisite symmetry, its form a regular icosahedron (Pl. II. fig. XVIII. Si). It is non-metallic like azote (Pl. II. fig. IX. Az), and, indeed, it may be said to be an atom of azote pressed down into a solid sphere. Its atomic weight is, of course, the same, namely, $2 \times 35 = 70$, *i.e.*, 14 when $H = 1$. Viewed in itself it must be a most inactive element, for its form is already most perfect, but it occurs in nature in union with an atom of oxygen on each pole, and, therefore, if stript of its oxygen, it must tend, under the law of redintegration, to reunite with two atoms of oxygen, or something else which may represent oxygen. It therefore represents silicon.

Silicium. — And here we may remark in passing, that perfectly spherical though silicon be in form externally, yet it has contents; it is not cellular. There are still ten units of force in its centre. Neither is OSiO duly differentiated, being wholly non-metallic. According to our theory, therefore, these ten units of the centre will secularly seek the surface, and that in the equatorial region, so as to expand the equator, for the form of silica is prolate. And thus they will ultimately metallise that region (see Pl. II. fig. XIX.) This done, silicon may now bear the name of silicium, since, though it must be still brittle, it may have a metallic lustre. And thus it may be, as we have found so often, that where chemists differ, both are in the right—the silicious element being at first metalloidal, and afterwards metallic.

As to the molecular structure of silica, we may have a still greater variety than we hinted with regard to its analogue $OCO = CO_2$, for in $OSiO = SiO_2$ the balance between oxygen and silicium (Pl. II. fig. XX.) is better, and the stability under a variety of arrangements will be greater, while, at the same time, by doubling and halving of volume, nearly the same relation may be maintained to the unity of specific gravity; and very dissimilarly constituted molecules may have the same specific gravity, and consequently, their experimental verification may be very difficult. As to the two normal molecules, composed of single atoms of silica,—namely, the isometrical and the differentiated dodecatoms,—neither of them can be the molecule of natural culmination, since each occupies only half a normal volume.

Here, then, let us remark, that while we have in the preceding genesis of silica obtained it in single atoms, the same material (lithia) must, when existing in a region where synthesis and unification prevail, give it in double atoms. And these double atoms, or chemical molecules, have a higher claim to morphological regard than single atoms, because they are of the sesquioxide type, that is, they are provided with oxygen not only on both poles, but on the equator also, and, therefore, are finely protected from the further attacks of this great corroder. Thus, taking two coupled atoms of lithia, and opening up one of them, and placing its two parts symmetrically and inversely on the poles of the other, and then applying pressure along the axis, we obtain the secular equation—

4. Lithia,  = OSi©SiO = $2SiO_2$.

Now, taking dodecatoms, isometrical and differentiated, of this doubled silica, we obtain normal specific gravities—

Quartz of fusion, $G = \frac{(OSi©SiO)^{12}}{AQ} = \frac{12 \times 300}{1620} = 2{\cdot}2.$ Exp. 2·2.

Crystallised Quartz, $G = \frac{(OSi©SiO)^{1+12+1}}{AQ} = \frac{14 \times 300}{1620} = 2{\cdot}59.$ Exp. 2·5…2·8.

It is also worthy of remark that one molecule of this double-walled silica will secularly tend to expand into three of the true silicic acid—

Silica, $(OSi©SiO)^{12} = 3.\overset{\dots 10 \dots}{\underset{4}{Si}O\underset{4}{Si}}$ Silicic Acid (see p. 94).

As to silicon itself, which the chemist has succeeded in obtaining in very small crystals, it appears to affect the differentiated dodecatom, &c.,

Silicon Diamond, $\frac{Si\overset{12}{Si}Si}{\frac{1}{4}AQ}$ or $\frac{\overset{12}{Si}\overset{32}{Si}\overset{12}{Si}}{AQ} = 2{\cdot}42.$ Exp. 2·34…2·49.

There is still evidence in many forms of silica in the crust of the earth that it existed originally as a hydrate; and Graham, that master of the mint of nature, has lately succeeded in constructing and bringing to light some fine hydrates, and more especially one which in general structure may be compared with the element of salt water in the present ocean (see p. 70). Thus, substituting a dodecatom of silica for a molecule of common salt, we obtain—

$$\text{Soluble Silica,}\quad \begin{matrix} \overset{3}{AQ}\ \overset{3}{AQ} \\ AQ(OSiO)^{12}AQ \\ \underset{3}{AQ}\ \underset{3}{AQ} \end{matrix} \quad \text{Silica, 7·7 per cent. Exp. 5 to 8·5.}$$

And this, when neutralised by an atom of potass on each pole, implies 1·88 per cent. of the alkali, Graham having found 1·85. By careful boiling, the two differentiating particles of AQ may be driven off in vapour, while the central dodecatom of silica, along with another, takes their place. We thus obtain the next symmetrical hydrate in which the silica is 15·5 per cent., which corresponds to brine (p. 71). But, doubtless, the primæval siliceous water contained only a single or a double atom of silica as a nucleus, instead of a dodecatom, giving no more than 0·63 or 1·26 per cent. of silica.

Beautiful also is the structure of the alcogels and glycerogels which Graham has constructed, in which alcohol and glycerine in molecules take the place of water. Thus, a dodecatom of which the poles are $(OSiO)^{12}$, and the body consists of ten molecules of alcohol $(C_4H_6O_2)^{12}$, instead of water, gives—

				Theory.	Exp.
Alcogel,	Alcohol,	$10(C_4H_6O_2)^{12}$	= 27600	88·5	88·13.
	Silica,	$2(OSiO)^{12}$	= 3600	11·5	11·64.*

The oxygen in silica being not only very dissimilar to the silicon, but also congenital and conformable, is of course very firmly held by it. But it is chased away when silica is heated in an atmosphere of chlorine, giving a liquid—

$$\text{Chloride of Silicon, G...}\ \frac{(ClSiCl)^{12}}{2AQ} = 1{\cdot}57.\ \text{Exp. } 1{\cdot}52.$$

Also fluorine, the baric isomorph of oxygen, drives off the latter with such force from silica, that if moisture be present the particles of silica are picked out of glass, &c., and every glass vessel is obscured, corroded, and eaten through; hence but little is known of this combination.

* Since the MS. of this page was sent to the printer, the admirable Graham has died—an irreparable loss to molecular science. Faraday's main work was the correction of misconceptions; Graham was directly bent on the interpretation of nature.

CHAPTER XIV.

THE DEVELOPMENT OF ROCKS.

The very short time during which any one man can live so as to observe nature has very naturally led people in general to believe that it is plants and animals only which develope and decay, or undergo normal periodic transformations. Rocks are popularly supposed to remain for ever the same, except in so far as they may be acted upon, and changed by forces applied to them from without, such as the weather from above, the waters around, or the volcano from beneath. Our theory finds no place for such a distinction. For the simultaneous weaving and unweaving of the beautiful web of molecular nature, the same aspiration after the spherical and the æriform, resisted by the same law of differentiation retaining matter in the concrete state, and in manifold forms, applies equally to all. The crystal, the gem, is no less a thing of beauty and of Providence than the plant or the animal. But with the great Creator a thousand years are as one day, and one day is as a thousand years. And in the actual creation greater changes in certain departments are accomplished in a single day than in certain other departments are accomplished in a thousand years. Still all, both the slowly and the rapidly changeful, are equally under the same laws, and equally held to absolute obedience to these laws. And just as a comparatively homogeneous embryo tends to be differentiated and to be developed into a variety of organs, so does a homogeneous rock tend to be differentiated and to be developed into a variety of minerals.

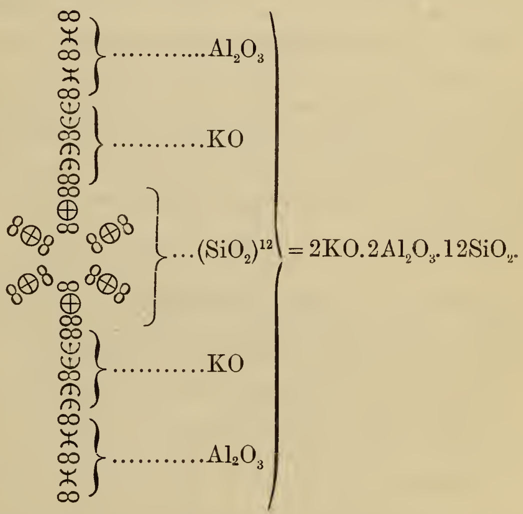
Let it not be inferred that while such growth and development is obviously possible in the yielding air, the region of plants and animals, it cannot be possible in the interior of a hard compact rock. Our theory relieves, let me not say Nature, but our own misconceptions of such a difficulty. Thus, in consequence of the fact that our elementary combinations give trigonal elements as their first forms, and after that pentagonal forms, from which, as we have seen, there result molecules, in which the numbers 12 and 20 prevail, while the volumes of these same elements and molecules are regulated by a ratio of equality, or that dichotomy which belongs to it, viz., the ratio $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 4, 8, 16, &c., it comes to pass, as molecular synthesis proceeds, that there is a play between material and volume, matter and space. That which, in point of material, may be represented by numbers such as 12 or 20, must be contained in a volume which possibly cannot be represented by either of these numbers, but perhaps by 4 or 8, or 16 or 32. Hence, accompanying atomic motions there must be many variations in density. And the progress of nature generally, in consequence of the secular action of atomic heat, must be from the more dense to the less dense, from the solid to the cellular. These principles we may illustrate in reference to felspar which, after quartz itself, is most abundant in the crust of the earth.

Felspar.—We have seen (see p. 137) that the single-walled or simplest molecule of silica is $(\ddot{Si})^{12}$ or $\ddot{Si}(\overset{12}{\ddot{Si}})\ddot{Si}$, and, as the specific gravity of the double-walled molecule shows, this molecule must occupy half a normal volume. Now, these dodecatoms, whether isometric or differentiated, will no doubt tend to be associated in groups of 12. But it appears that such a group of 12 is not so bound together as to constitute an unity, such as a molecule of quartz. Were this the case, the specific gravity of quartz, instead of being 2·2 or 2·6, would be 3·3 or 3·9. But the next step in molecular synthesis ought to provide for their unification, or the investing of the groups with individuality. But this cannot be accomplished, taking them as they are. Were they, after having been unified, to retain their former volumes, the resultant volume being 12 half volumes, would be 6 normal volumes. But the number 6 is not volumetric. The nearest volumetric numbers are 4 on the one hand and 8 on the other. The matter, therefore, which when it consisted of 12 individualities occupied 6 volumes, must, when it becomes one individuality, adjust its particles so that it shall occupy either 4 or 8 volumes. Now, of these the latter in the order of natural development is to be expected, and the space being so much larger than the matter to fill it, the entrance of more matter into that space may be expected. Now, for such additions of matter to molecules, according to our theory, there is always room, except in extreme cases, by the further differentiation of the poles of the molecules. Let us, then, take our simple isometrical molecule $(\ddot{Si})^{12}$, and carrying back our thoughts to the epoch when silica, &c., existed as yet as a hydrogel or fully developed hydrate, or rather when the materials of silica, &c., existed as elements of lithium and oxygen, movable in relation to each other, let us differentiate the poles of $(\ddot{Si})^{12}$ to the utmost degree possible by these two elements, and see what we obtain.

This will not imply indefinite differentiation. It is limited by the number of ways in which atoms of lithium may apply themselves to each other, and to atoms of oxygen. Now, in reference to lithium, these ways are only three, viz.—

Taking, then, a coupled atom of lithia with the two oxygens as poles, and the two lithiums locking into each other as the body (for this is the simplest molecular structure which can be at once stable in itself and secure from change by the action of surrounding oxyyen), as the element of our first mineral substance, and then these in simple dodecatoms, that is, taking the simple dodecatom of silica wherewith to begin the mineral kingdom, let us place on its poles, symmetrically with an atom of oxygen between, those other two combinations of lithium in couples which are not already employed in forming the body. And alongside the differentiated dodecatom which we thus obtain, let us place the usual chemical symbols for the substances which must have resulted, according to our theory, when the desiccation of the mass, and the consolidation of the hydrogen (into calcium) has taken place. And, now, along with stable quartz, we shall have—

Felspar Orthoclase,



That this construction gives the true composition of an atom of orthoclase will be admitted by the chemist, in consequence of his happy error of estimating oxygen at 16, involving silica as 28, whence a whole molecule, or molecule with two poles, is obtained, instead of a half molecule, or structure with only one pole, as is usually the case when $O = 8$. Thus, in Watts' Chemical Dictionary—a perfect marvel of chemistry—the formula of felspar-potass is $K^2O.Al^4O^3.\ 6.SiO^2$, which, restoring the true atomic weights of O and Si, is obviously the same as I have here described.

But this differentiated dodecatom is, according to our theory, only a single molecule, a member in a larger one, which constitutes that true individuality whose volume is in relation with the normal unit-volume of concrete matter, there being 12 of the former in one of the latter. We have also seen reason for believing that this latter shall occupy, not 12 half-volumes or 6 volumes, but 8—that is, half an ice volume. Let us, then, try for the specific gravity on this theory—

$$\left.\begin{array}{l}\text{Potass-}\\\text{felspar,}\end{array}\right\} G = \frac{(OAlOAlO.KO.(O\overset{12}{Si}O).OK.OAlOAlO)^{12}}{\frac{1}{2}ICE}\left\{\begin{array}{l}=2{\cdot}59.\ \text{Exp.}\\ 2{\cdot}53\ldots2{\cdot}62.\end{array}\right.$$

But here the eye becomes already fatigued in attempting to catch the symmetry amid such a host of letters. Let us, then, abbreviate thus—Instead of OSiO, or $\ddot{Si}$, let us write the familiar symbol $\ddot{\$}$, which fills the eye and the purse, as silica does the strata. Instead of OAlOAlO or $\dddot{Al}_2$, let us write, as has been already proposed, $\dddot{\mathbb{A}}$, the double-faced letter expanding the formula much less than the numeral 2. And instead of NaO or $\dot{N}a$, let us write $\dot{N}$, since N, considered as the symbol of nitrogen, loses all specific value, according to our views.

So much for potass-felspar. It follows from our theory, however, that an accession of oxygen in the region where this molecule exists will tend to induce a change upon it, for such accession would most probably develope a peroxide of potass. Now, a peroxide of potass, according to our theory, tends secularly to dedouble into protoxide of soda. Thus—

$$2KO_3 = 4NaO + 2H.$$

And hence, by a secular transformation, we may from a felspar-potass possibly obtain a soda-felspar, as also, in a reverse condition of existence, we may obtain a potass from a soda-felspar.

We may also, obviously, have both potass and soda in the same composite dodecatom, as, for instance, soda in the two polar molecules, and potass in the ten of the body; and even this we may attempt to represent with letters as symbols, so that the eye may catch the symmetry. To such an attempt I append also the chemical analysis of such a felspar. It shows both the accuracy in percentages which it is possible to attain by chemical analysis, and the necessity of attending to small quantities of subordinate constituents. They are often regarded as impurities, and are thrown aside. But in the light of our theory they present themselves as integrant parts of the molecule, and indicate interesting epochs in its history. In order to manifest the structure, it is necessary here, however, to decompose the compound dodecatom into a body consisting of ten single dodecatoms, with two poles, consisting each of one dodecatom, according to the type—

$$(\overset{12}{X}\overset{12}{X}X)^{} = XXX_{12}(XXX)^{10}_{12}XXX_{12}$$

Substituting soda $\dot{N}a$ for potassa $\dot{K}$ in the polar elements, we thus obtain—

$$\left.\begin{array}{r}\text{Soda-Potass}\\ \text{Felspar,}\end{array}\right\} G = \frac{\dddot{Al}_2\dot{Na}\ddot{Si}_{12}\dot{Na}\dddot{Al}_2(\dddot{Al}_2\dot{K}\ddot{Si}_{12}\dot{K}\dddot{Al}_2)^{10}\dddot{Al}_2\dot{Na}\ddot{Si}_{12}\dot{Na}\dddot{Al}_2}{\frac{1}{2}\text{ Ice vol.}} \left\{\begin{array}{l}=2{\cdot}55.\\ \text{Exp. } 2.55.\end{array}\right.$$

				Theory.	Abich.	
Felspar,	12 ×	$12SiO_2$	21600	65·14	65·72	From Baveno.
	12 ×	$2Al_2O_3$	6240	18·82	18·57	
	10 ×	2KO	4700	14·17	14·02	
	2 ×	2NaO	640	1·35	1·25	

(Miller's Mineral. p. 367.)

And here the necessity of some shorter and simpler symbols again appears. The eye is bewildered, and can scarcely catch the symmetry. Since, therefore, in the mineral kingdom atoms of aluminum always occur double, and both they, silicon, sodium, and potassium, always occur in union with the same quantity of oxygen, might we not use a single symbol for aluminum, and omit the marking of the oxygen altogether. This, with the omission of the small letter following the capital in the literal symbol, would give a great simplification; and in this the eye could take in and see the symmetry, viz.—

$$AN\overset{12}{\$}NA(AK\overset{12}{\$}KA)^{10}AN\overset{12}{\$}NA,$$

which is soda-potass felspar, as above, with the simpler symbols just proposed. But perhaps this is carrying it too far.

From what has been said, it appears that felspar is the readiest product of the complete differentiation of the two primal elements, oxygen and lithium, the supply of oxygen being supposed to be abundant. Viewed in reference to non-metallic, metalloidal, and metallic, felspar may be said to consist of fully differentiated molecules. Thus, supposing the siliceous base of the body to exist as silicon, the body $(OSiO)^{12}$ is equally metalloidal and non-metallic, while the poles, apart from their oxygen, are wholly metallic (Al + K + Na). It also consists of all the three usual oxides, protoxide (KO or NaO), deutoxide (OSiO), and sesquioxide (OAlOAlO). Therefore, nothing more can be done for it to impart to it greater stability in this respect, and to retain it as it is. But it cannot remain for ever as it is. It must tend to break up and to be developed into a great variety of other minerals, and so to be the source and parent of a great many others. What these are it will form a pleasing inquiry of the future to discern, when chemists and mineralogists have returned to that belief which the history of philosophy gives as the catholic belief of the reflective mind, namely, that in the ground there must be but one kind of matter. At present, we only remark that when, as in the case of felspar, the differentiation of the poles of a molecule has been completed, and, consequently, a considerable departure from the spherical has resulted, then, under the unceasing operation of the law of sphericity, a new system of action must be set up. The poles must now become the foci of aggregation, and our ellipsoidal molecule must tend to part at the equator, and to dedouble into two spherical molecules. But such purely geometrical phenomena are very seldom realised in material nature. They are rather the limits or types of molecular action than the actual results of that action. And what we are usually to expect in reference to a molecule that is fully differentiated in every respect, or, since that is so highly composite as to embarrass us, let us say a molecule of felspar, is the individuation of the outstanding polar elements by the aid of material obtained from the solution or decomposition of the body of the molecule, differentiation being still kept up by the elements of that body taking up a position as differentials. Applying these views to the molecule of felspar, we obtain—

$$\text{Felspar, }\left\{\begin{matrix}\dddot{\mathbb{A}}\dot{K}(\ddot{\$})^{12}\dot{K}\dddot{\mathbb{A}}\\ \dot{K}\dddot{\mathbb{A}}(\ddot{\$})^{12}\dddot{\mathbb{A}}\dot{K}\end{matrix}\right\} \div \ddot{\$}\dddot{\mathbb{A}}\ddot{\$} + \ddot{\$}\dot{K}\ddot{\$} + \ddot{\$}\left\{\begin{matrix}\text{Dry clay.}\\ \text{Soluble glass.}\\ \text{Sand.}\end{matrix}\right.$$

Now, of these products of decomposition the bisilicate of potash can only be a transitional substance, for the potass must be. Thus, just as $\acute{K}O_2 = 2CaO$, so $\acute{K}O_5 = Al_2O_3 + 3HO$ (see chap. VI.) Instead, therefore, of $\ddot{\$}\dot{K}\ddot{\$} + \ddot{\$}$ for ever, there will ultimately be $\ddot{\$}\dddot{\mathbb{A}}\ddot{\$} + \ddot{\$} + 3aq.$ The soluble glass stuff will secularly be transformed into moist clay and sand. The disintegration of the rock will be accomplished. The sphericity of the planet will not be interfered with for ever by the peak and the precipice, and mineral nature will be prepared for a vegetable kingdom.

Mica.—But yet, such a crisis considered as universal must be indefinitely postponed. As soon as by the transformation of felspar 12 atoms of bisilicate of alumina $\ddot{\$}\dddot{\mathbb{A}}\ddot{\$}$ shall have been constructed, they may form into a dodecatom. And if to this isometrical body bisilicate of potass be applied as a differential, especially if accompanied by the three atoms of aq, which are proper to it, we may expect that both the potassic silicate and the entire molecular structure will be eminently stable. Now, although in the present epoch, differentiation in the mass has commonly gone much further than this, yet some micas have been analysed whose composition agrees with our construction. Thus,

$$\text{Mica, } \frac{\overset{12}{\dot{H}aq\dot{H}\dot{K}\$\dot{K}(\$\ddot{A}\$)\dot{K}\$\dot{K}\dot{H}aq\dot{H}}}{2AQ} \;\ldots.\; G = 2{\cdot}9. \quad \text{Exp. } 2{\cdot}82.$$

White Mica,			Theory.	Kussin.	
	$26SiO_2$	3900	47·4	48·1	from Zsidovacz in Hungary.
	$12Al_2O_3$	3120	37·9	38·4	
	4KO	940	11·4	10·1	
	6HO	270	3·3	3·4	

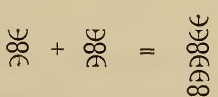
Hornblende.—Our theory of the alkali-metals implies that while as yet they retain all the matter proper to their genesis, and are consequently symmetrical on each side of the equator, as also each half symmetrical in reference to its own centre, molecular action, when existing in an analytic phase, tends to give the first couple of the following equations, and when in a synthetic phase, the second couple—

Analytic,	OK̒O	=	2.CaO	Lime.
	ON̒aO	=	2.MgO	Magnesia.
Synthetic,	2.MgO	=	ON̒aO	Soda + HO.
	2.CaO	=	OK̒O	Potass + HO.

Between the alkali and the alkaline earth metals, therefore, we are to expect many alternations and substitutions in nature.

Where, on the other hand, the reduction of elements has been going on, where ᴗ has been undergoing reduction to ⍦, another result is to be expected; for in this case so much hydrogen will be developed that it will tend to rob its neighbourhood of oxygen, lapsing along with it into aq, unless the oxygen be so engaged as to be protected from its attacks. In such regions of reduction, therefore, we are not to look for such combinations as OKO or ONaO. The metals may be stript, even, of all their oxygen and reduced to nakedness, as K and Na. But

Two atoms, one of Sodium, the other of Sodhium,



One atom of Potass.

Instead of naked sodium, therefore, in nature, we may have potass.

And when this oxide is striped of its exposed atom of oxygen what shall we have? At this epoch we may safely infer that the atoms of ᴗ implicated have been reduced to atoms of ᴗ, and to find what we shall have, we need only to look at the structure of the atom of potassium.

This done, we obtain, as the ultimate product of the secular transformation both of potassa and soda, of magnesia and lime, the equation—

Reduced potassium } ᴗᴗ8ᴗᴗ = ᴗᴗᴗᴗ8 = FeO Protoxide of Iron.

And generally during the development of moisture, by the reduction of ᴗ to ᴗ when in union with abundant O.

$$\left.\begin{array}{l} 4\dot{Mg} = Na^2 \\ 2\dot{Ca} = Ca^2 \end{array}\right\} = K + HO = FeO + 4\ HO.$$

After felspar, therefore, of which the characteristic is the presence of the alkalies, soda and potass along with silica, we are to look for abundant rock in which these alkalies appear now in the form of magnesia, lime, and iron-oxide. And such precisely is hornblende, which, after silica and felspar, is perhaps the most abundant rock-constituent of the crust of the earth.

The molecule of hornblende seems to consist of a central dodecatom of silica encrusted with *lime* all over its body, but carrying a dodecatom of silica, on each pole, its body encrusted with *magnesia*, these three dodecatoms being rusted into one combination by two atoms of iron-oxide run in between. Such a structure cannot be represented on a plane, like that of the page. But by dividing the $10\dot{Mg}$ and the $10\dot{Ca}$ into 5 + 5, so as to maintain symmetry, perhaps some conception may be given thus—

$$\text{Hornblende}\ldots\underset{\underset{\dot{Mg}}{}}{\overset{\overset{5}{\dot{Mg}}}{(\$)}}{}^{12}\dot{Fe}\underset{\underset{5}{\dot{Ca}}}{\overset{\overset{5}{\dot{Ca}}}{(\$)}}{}^{12}\dot{Fe}\underset{\underset{5}{\dot{Mg}}}{\overset{\overset{5}{\dot{Mg}}}{(\$)}}{}^{12} \div 2AQ \ldots\ldots G = 2{\cdot}82.\ \text{Exp. } 2{\cdot}9.$$

Analysis,

		Theory.	Bonsdorff.	
$36SiO_2$	5400	59·0	59·7	From Taberg.
$20MgO$	2000	21·8	21·1	
$10CaO$	1400	15·3	14·3	
$2FeO$	360	3·9	3·9	

According to this view hornblende is not made up into such good molecules as felspar is. It will, therefore, be a more restless mineral, and more powerfully genetic of others. The structure of repose gives us as limiting specific gravities, 2·12 and 4·23—mean, 3·17.

Talc.—When segregation takes place, or the $\dot{\text{lime}}$ in the molecule is otherwise substituted by the prevailing magnesium, and two more atoms of iron-oxide are added, so as to form ferreous poles also for the polar dodecatoms, a compound dodecatom becomes possible, and we appear to obtain the interesting mineral—

$$\text{Talc, } Fe\overset{\overset{5}{\dot{Mg}}{}^{12}}{\underset{\underset{5}{\dot{Mg}}}{(\$)}}\dot{Fe}\left(\begin{matrix}\overset{5}{\dot{Mg}}\\ (\$)^{12}\\ \underset{5}{\dot{Mg}}\end{matrix}\right)^{10}\dot{Fe}\overset{\overset{5}{\dot{Mg}}}{\underset{\underset{5}{\dot{Mg}}}{(\$)}}{}^{12}\dot{Fe} \div 8AQ\ldots G. = 2{\cdot}65. \text{ Exp. } 2{\cdot}6\ldots2{\cdot}8.$$

			Theory.	Lychnell.
Analysis,	$144SiO_2$	21600	62·9	63·1
	$120MgO$	12000	34·9	34·3
	$4FeO$	720	2·9	2·3

Olivine.—But of all finely individualised minerals of these constituents olivine presents itself as the simplest, the element for constructing the body of the molecule being now the symmetrical combination, $\dot{Mg}\ddot{\$}\dot{Mg}$.

$$\dot{Fe}\ddot{\$}\dot{Fe}(\dot{Mg}\ddot{\$}\dot{Mg})^{12}\dot{Fe}\ddot{\$}\dot{Fe} \div AQ = 3{\cdot}22. \quad \text{Exp. } 3{\cdot}3\ldots3{\cdot}4.$$

Olivine,	$14SiO_2$	2100	40·2	40·1	from Somma.
	$24MgO$	2400	45·9	44·2	
	$4FeO$	720	13·8	15·2	

This, therefore, is just such a mineral as we may reasonably expect in such hastily constructed minerals as aerolites.

Serpentine.—In the preceding pages we have often seen the superiority of the sesquicombination (consisting of the same element in the equator and in each pole), over that which has only similar poles, while the equator is wholly dissimilar. If, then, the characteristic constituent of talc be $\dot{Mg}\ddot{\$}\dot{Mg}$, we may expect some other more stable mineral and rock, whose characteristic constituent shall be $\dot{Mg}\ddot{\$}\dot{Mg}\ddot{\$}\dot{Mg}$. Now, when of this sesquicombination we form a dodecatom, and encase it in moisture, and differentiate it by an atom of iron-oxide on both poles, it looks as if we had obtained—

$$\text{Serpentine, } \dot{Fe}(aq\dot{H}\dot{Mg}\ddot{\$}\dot{Mg}\ddot{\$}\dot{Mg})^{12}\dot{Fe} \div 2AQ.G = 2{\cdot}66. \text{ Exp. } 2{\cdot}5\ldots2{\cdot}6.$$

		Theory.	Kerstin.	
$36MgO$	3600	41·7	41·5	From Swartzenberg.
$24SiO_2$	3600	41·7	40·3	
$24HO$	1080	12·6	12·9	
$2FeO$	360	4·2	4·1	

Thus does it become possible by the aid of our molecular morphology to construct a mineralogy, which may stand by the side of botany and zoology, all the three being viewed in reference to their histology and development or genesis as species. As to external form, in reference to any of the three, little can be done at present either as deduction or verification. The same principles of morphology apply to all. And in all, the problem "to find the form of the individual," is far too complicated to admit of solution in the existing epoch of science. All do, indeed, according to our philosophy, aim at that form which is most perfect. All aim, each in its own behalf, at the construction of a contour which, on its confines with the ambient, shall be spherical, or be defined, as we may say, by a regular polyhedron, which has an indefinitely great number of facets, leaves, scales, or epithelia. But even in the mineral kingdom in which, from the homogeneous structure of the interior, the external forms are far more simple than they are in plants and animals, the polyhedra constructed have only a finite number of sides, and are comparatively seldom regular or monometric. The specific shapes of the constituent molecules determine specific resultants of force of unequal power in corresponding directions, and these so counteract and interfere with the law of symmetry and sphericity in its general bearings, that crystallography both is now, and must remain for the present a merely descriptive science. It is, however, no longer without a scientific directrix, since our theory shows that all crystals ought to be studied in reference to the circumscribing sphere as the general type.

As to plants and animals, their highly differentiated internal structure, the cosmical forces of the sunbeam on the one hand, and of gravitation on the other, and, more than all, the specific assimilative power of the embryo, ever insisting on the parental form as the development proceeds, cause such departures from a spherical contour that, generally speaking, it is only previous to development that this form is obvious, at least, in those species which do not enjoy the repose of a life in which their gravitation is balanced in the waters and in which the entire individual attains a considerable size.

Moreover, as to the assimilative power of the embryo, though it may be due merely to the normal operation of the physical forces of the constitutive molecules, as in the case of crystals, yet if anything in science is certain it is this, that these physical forces themselves have been so regulated at first that they may construct forms which shall subserve the interests of sensibility and intelligence. If anything is certain it is this, that intelligence and feeling presided when the physical forces were appointed to be as they are, and to act as they do. To doubt or to deny this is to renounce, not merely all philosophy and all theology, but humanity itself, in all that is most worthy of the name.

CHAPTER XV.

THE DEVELOPMENT OF METALS.

In what has preceded I have attempted to follow one of the leading lines of what, according to our theory, is the normal course of molecular synthesis. And it will not be denied that the molecular structures which have presented themselves to us as we have proceeded, agree so far as they have been compared with those of nature and the laboratory in their atomic weights and their specific gravities, in their chemical and physical properties generally, in their juxtapositions, and in the quantities to be expected of them. The comparison has not, indeed, been carried into many details, because a book which can only have a few purchasers by an author whose means are limited, ought to be a small one. And, besides, the evidence in favour of a hypothesis grows far faster by showing its all-embracing power, than by showing how completely it can explain in detail the phenomena of a few objects selected by its author. Details any student can easily compare for himself. But a through-going sketch being possible only after the leisure of a lifetime devoted to the comparison, could not be done by every one. Of such a sketch it is also (and, at any rate) desirable to preserve some trace. For the present day the author, grown wise in this respect by experience, contemplates little more than the placing of a copy in some public libraries, where they will be found when their time comes.

I have said that *one* of the principal lines of molecular synthesis has been followed. Now, it must ever be remembered that the whole action of nature, even in one particular sphere, as, for instance, that of molecular synthesis, is never in a single line. Rather that action is radiant, step after step, and that along secondary lines as well as the primary; and hence the hopelessness of a truly natural classification in any branch whatever of natural history; for scientific thought is wholly incapable of radiation; its very characteristic is to hold on in one connected line, and to refuse to respect even a dichotony otherwise than as a distraction.

Such a method, therefore, as has been pursued in these pages, implies a number of subordinate lines of molecular synthesis rising out of the principal line on all hands and at every step, and these giving molecules of what I have called common density, as well as still more, molecules of light, baric, and barytic densities which have hitherto been scarcely touched upon.

This, in the future, in other hands.

Meantime, I propose here to add a few notes of some metals which have obtruded themselves in my way, and which, though of little importance in the economy of nature perhaps, are yet interesting in a scientific or a social point of view.

We have seen what a rich variety of molecular changes tend secularly to result from the fact that the same materials, namely, five bitetrads, may, according as the mode of action in the region calls for negative or for positive forms, constitute either an atom of oxygen or an atom of sulphur. Still richer is the variety that results from the fact, that the same materials when barytic (that is, when each unit is a condensed tetrad), constitute in analogous conditions either an atom of barytic oxygen (tetroxygen), or an atom of Tellur. (The tellurium of chemistry is to us $\overset{4}{Te}$, the tetratom isamorphous with $\overset{4}{S}$, *i.e.*, sulphur.)

Under the laws of development and sphericity we thus obtain the secular equations,—

$$\overset{5}{H} = \left\{ \begin{array}{lll} & \text{Barytic.} & \text{Singled.} \\ \text{Oxygen......} & \mathbf{O} = & 4O \\ \text{Sulph.........} & Te = & 4S \end{array} \right\} = \text{Zinc} = \overset{20}{H} \text{ (see Pl. I. fig. v.)}$$

(Spherified.)

The first element, barytic or abyssal oxygen, or tetroxygen is, of course, unknown to the chemist; for even fluorine, its isomorph, though much less parasitic and powerful, nay, ozone, or rather common oxygen in single atoms, are scarcely known. But by its secular unfolding into four atoms of common oxygen, barytic oxygen proves invaluable among abyssal elements to the economy of nature. The sulphic form of the same number of barytic bitetrads when in tetratoms, is known as tellurium. In its spherified form as $\overset{20}{H}$, it must constitute a fine though heavy metal, isamorphous with zinc. But, no doubt, since it is isometric, its poles will be generally differentiated by some comparatively light metal of the same order. When unfolded it gives four atoms of zinc, just as an atom of sulphur when spherified gives one atom. Of this an illustration has already been given (see p. 42) in the secular equation—

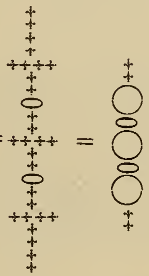
$$\text{Sulphur vapour....} S\ S\ S = Zn S Zn \text{...Zinc Blende.}$$

Here, then, we have an instance of one of the modes by which the metalloidal is secularly transformed into the metallic, namely, by a simple improvement of the symmetry of the form, a movement into the spherical. A still more important mode, however, is the inversion of the tetrads of which the molecular form consists, so that the summits of the tetrads, from being centrad, become peripherad, and the whole surface is hung high by particles of the medium of light itself. But this I need not now enlarge upon, having published the whole theory of Metallicity in 1856, and subsequently in 1860 and 1868.*

As to the instance given here, the student may reasonably ask, If zinc may thus be produced in so many ways, why is there not more of this metal in nature than we find? To this the answer is, that sulphur vapour in raking up along the fissures and porous beds of rocks cannot be expected generally to remain pure and homogeneous. It will, on the contrary, be generally differentiated. And here we may remark that the number of the differentiating elements determined by the law of symmetry will be either two or four.

Lead.—Supposing the differentiating element to be the simplest possible of those forms, which, when placed between atoms of zinc, could act as an undecomposable coupling-joint, that is, boron; then, admitting one atom of this element between the three atoms of sulphur, that is, two atoms in all, and supposing not only the two extreme atoms of sulphur, as in zinc-blende, but also the central atom, to be secularly spherified, while one sulphic atom is retained on each pole to differentiate the resulting metal, and to engage the residuary sulphic matter, we obtain—

Sulphuretted sulphur vapour fixed by Boron and spherified, } =



= { 104 Metal, 16 Sulphur, when H = 1 } Galena.

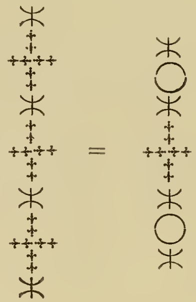
Instead of zinc, then, where boron in single atoms can be had to solder three atoms of zinc during their genesis undecomposably together, we shall have another metal, its atomic weight $(3 \times 32) + (2 \times 4) = 104$ (or possibly less by 2), that of lead being commonly estimated at 103·5.

* See "Elements of the Economy of Nature" (a fragment). Second edition. London, Chapman and Hall, 1856. Chap. VI., On the Lustre of Molecules. Also in "The First Lines of Science Simplified, and the Structure of Molecules Attempted." Edinburgh, Sutherland & Knox, 1860. See also "A Sketch of a Philosophy," Part II., Molecular Morphology, Williams and Norgate. Chap. IV., "The Nonmetallic and the Metallic, and their Mutual Relations."

Along with zinc-sulphuride, or blende, therefore, in veins and beds, we may look for abundant lead-sulphide, or galena (see p. 43).

Indium. Cadmium. Tin.—As has been stated, the differentiation of the element of sulphur-vapour may be effected by 4 as well as by 2 atoms of some other light element, that is, 2 on the poles as well as 2 in the axis. This will render each polar atom of sulphur symmetrically differentiated, and, therefore, separable from the sulphur as a new element when the differentiating matter cannot be torn off in the laboratory. Further, such solidarity we may expect when the differentiating matter is an atom of a light metal, for such a metal may be locked into, or welded on the poles of the atom of zinc. Now, for such a situation and such a result three light metals immediately present themselves, namely, mineral or aerial lithium, magnesium, and aluminum, then, after a long interval, calcium and sodium. Taking the middle metal as an illustration, we obtain the secular equation—

Sulphur vapour fixed by Magnesium, and spherified on the poles.



Metal 2 × 56, Sulphur 32, when H = 1 } Greenockite.

The three metals just named give three whose structures are of the type fig. xxx. Pl. II. and their full atomic weights—

	H = 5	H = 1	
LiZnLi	40 + 160 + 40 = 240	48	Indium.
MgZnMg	60 + 160 + 60 = 280	56	Cadmium.
AlZnAl	70 + 160 + 70 = 300	60	Tin.

The last-named metal, however, appears usually to have quite another genesis. In short, its dioxide appears to be a corundum in which the medial atom in the alumina is barytic oxygen instead of common oxygen. The secular expansion of this combination will thus be represented by—

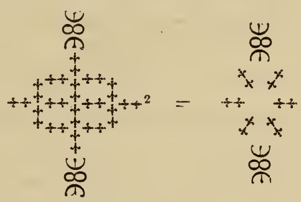
Mesobarytic Corundum, } OAl**O**AlO = OAl$\overset{20}{\text{ǂ}}$AlO = OAlZnAlO = OSnO...Tinstone.

and here, plainly, we are in the neighbourhood of many heavy but imperfect and obscure metals.

Let us then return to sulphur and its products when spherified.

Thallium.—When the metals which fix themselves on the poles of the atom of sulphur are heavy and powerful, we may then expect as the equatorial part of the structure, and consequently as the body of the metal secularly resulting, more than a single atom of sulphur. And, if so, how many? Now to this it is to be answered, that 5 atoms of sulphur, that is, a couple applied symmetrically to each other as an axis, and three on the three equatorial arms of this axial couple, form a very symmetrical group. They also admit beautifully of being formed into a spherical icosahedral group of $\overset{20}{S}$ analogous to $\overset{20}{H}$. They are, therefore, suitable for forming the body of a metallic element, provided some comparatively powerful metallic atoms be locked upon the poles. Taking sodium for this purpose, we obtain as a secular equation—

Hypersulphuride of Sodium spherified,



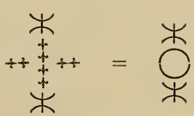
Thallium;

for the atomic weight of the composite metal is $115 + (5 \times 160) + 115 = 1030$; that is, 206 when $H = 1$.

All these metals are given to nature according to our theory and the genesis which has been here given of them, by the secular transformation of sulphur or of tellurium, or of barytic oxygen, which are the secular equivalents of each other. Now, selenium and baric oxygen, or fluorine (which are not secular equivalents of the preceding), must also under the same transformations give their metals. And here we are to expect a higher lustre, because selenium is made up wholly of hydrogen, and hydrogen has the highest refractive and reflective power of all elements.

Silver.—A simple selenide of aluminum, when the selenium is spherified into an icosatom of baric hydrogen for a body, and the aluminums are locked on the poles, gives—

Selenide of Aluminum spherified,



Silver.

The atomic weight is $70 + 400 + 70 = 540$; that is, 108 when $H = 1$.

And here our theory suggests at least another metal whose polar parts shall be magnesium instead of aluminum, and which shall differ from silver as cadmium does from tin. Its atomic weight must be the same as that of lead, but it must be more valuable in the arts than such lead as has been noticed two pages back.

There may also, possibly, be a metal with lithic poles, and therefore analogous to sodium, whose atomic weight will be 40 + 400 + 40 = 480; that is, 96 when H = 1. Indeed there must be many metals here. But when it is considered that simply by that secular change by which the 5-fid poles of such metals are gathered up into atoms of hydrogen or of boron, with a loss of only 2 or of 8 from their atomic weights on the hydrogen scale, their character as metals is completely changed, so that from being ductile and malleable they become brittle and refractory, it will be seen that this field is too extensive, and verification is too difficult for us to touch upon them at present.

Mercury.—This metal, which continues in the molten state at the still existing temperature of our planet, resembles very perfectly in this feature and in its general appearance, an alloy of potassium and sodium, which constitutes a differentiated dodecatom, namely,

$$\text{Liquid Alkali metal,} \quad \text{Na}\overset{12}{\text{K}}\text{Na or KNa}\overset{10}{\text{K}}\text{NaK.} = 2(\text{NaK}_6).$$

But this alloy is very light, while mercury is very heavy. Moreover, we have seen that the sodium-form tends to double its poles so as to become a potassium-form, as also that the synthesis of elements of lithium on the same axis does not go beyond the number in the potassium-form. Now, then, let us assume a wholly baric potassium. As to its atomic weight, just as unreduced common potassium consists of 5 joints, each of which weighs 40, so baric potassium must consist of 5, each of which weighs 100. The atomic weight of a baric potassium, therefore, must be 500; that is, 100 when H = 1. Such a metal, therefore, agrees in atomic weight with mercury, and the functioning of mercury in many respects has been observed by the chemist to be analogous to that of an alkali metal. May not mercury, then, be baric potassium? But here, under the law of secular development and sphericity, a very remarkable and a very beautiful phenomenon presents itself. The medial atom here, that is, baric oxygen (fluorine), when secularly expanded and spherified, is resolved into $\overset{20}{\text{H}}$, an exquisite metallic icosatom (see Pl. I. fig. v.) Further, the 4 baric lithiums which constitute the polar regions of the baric potassium, are composed precisely of 4 × 5 = 20 atoms of selenic or baric hydrogen. Moreover, under the sustained operations of the law of sphericity, they must secularly tend individually towards the equatorial region. Now, in that region there is already an exquisite metallic nucleus, viz., $\overset{20}{\text{H}}$, with precisely 20 outstanding points to receive them. They will, therefore, secularly settle upon them. And thus may we expect, as a product of the secular transformation of an atom of baric potassium, an exquisite spherical metallic element, double walled, the inner wall and nucleus consisting of hydrogen in the dense state, the outer wall of a coating of the element which, according to our views, gives silver its brilliancy, the atomic weight of this new metal being that of mercury.

Mercury, then, according to this theory of its genesis, comes out when viewed historically as a dimorphous metal. Further, it may be shown, that in the molecule of the sulphuride (which is its usual mode of occurrence), one of the atoms of mercury must have spherified, while the other still retains the alkali form. Thus, mercury in both forms may coexist in the same epoch of our planet. But being so dissimilar, if both meet they will unite and cohere perhaps powerfully. Now, if so, mercury in such cases will seem to have an atomic weight of 200, and manifold chemical powers and complications will result, as is known to be the case in the laboratory. But on this subject we cannot enter; let us rather bring these remarks to a close by a word on—

Gold.—If we descend as low as possible, what we must find, according to our theory, is barytic matter, the tetradic tetrads and bitetrads grouped in the manner which satisfies most completely the ideas of sphericity and density. The group of tetrads which is at once most dense and most spherical is, as we have seen, a group of 20, a summit of each in a common centre; thus constituting an icosahedron (see Pl. II. fig. XVIII.) Taking now three such icosatomic forms of barytic matter, all on the same axis, as the smallest number which fulfils the law of symmetry by having an equator and two poles, let us fill up the spaces between them also with barytic matter. It will be found that for this purpose ten baric tetrads are required between each icosatom, as also that these ten just constitute an atom of barytic oxygen or tetroxygen. And now we have a barytic sesquicombination, possessing a normal molecular individuality. As to form, it is a short cylinder with rounded ends, consisting of the heaviest matter—its surface determined by 60 equal triangular facets, 5 of them terminating each pole.

Let us now follow its normal development. In due time, by the secular operation of the atomic heat in the centres of each of the five constituents of this cylindrical form, the centres of the three icosahedral particles will be emptied of matter. The three groups of 20 tetradic units there will be projected upon the surface; whence the icosahedrons will now have become metallic, and isamorphous with $\overset{20}{H}$ (Pl. I. fig. v.), as in other similar cases. Meanwhile, each of the two barytic oxygens or tetroxygens may have been unfolding into 4 atoms of common oxygen. This for the first epoch. As to the further differentiation and development of such a combination it may be long postponed.

But during the next epoch the metallic icosahedrons being isometrical, must tend to become differentiated in form. Now this they will do by the gathering together of the five tetradic units in two opposite 5-fid regions into atoms of boron, in the same way as we have seen H^{20} become HSiH (see Pl. II. fig. xxi.)

And then, during the succeeding epoch, the metallic icosatom thus differentiated, and which is precisely barytic silicium, may unfold into four atoms of common silicium.

Thus, from one symmetrical morsel of matter in the most dense state we obtain the elements—oxygen, boron, and silicium.

Now, we have seen that boron tends to form into a sesquioxide (see p. 55), which is undistinguishable from silica, while silicium also tends to lay hold of oxygen and become silica.

The main product, then, of the secular expansion and development of our most deep and dense matter will be silica.

But in order that such transformation may be complete, the original matter does not supply a sufficient quantity of oxygen. We are, therefore, to expect other substances less highly oxygenated than silica, perhaps even metals in the reguline state.

And more especially if two atoms of boron, of which, as we have seen, there must be an abundant supply, place themselves between three of the still surviving barytic metallic icosahedrons, there will, according to these views, result a metal, the structure of whose atom is the same as that of lead (see p. 151), but which must be much more stable and perfect every way than lead, since each of the 5 parts of which it consists has attained to a cellular state. What may it be! Its atomic weight, when none of its constituents have been lost during the development, must, when the borons are of the heavier sort, be $320 + 20 + 320 + 20 + 320 = 1000$, and when the borons are of the lighter sort, $320 + 15 + 320 + 15 + 320 = 990$; that is, 200 and 198 when $H = 1$. Now, Berzelius fixed the atomic weight of gold at 198·25; and if subsequent experimenters have found it to be somewhat lighter, this is only what is to be expected of a substance which, when complete, consists of a thousand elements, each of which is capable of being driven off, and of being engaged elsewhere, or by itself. If this be gold, then (which determines to such an extent the aspirations and the actions of men), viewed as in the quartz, &c.—in which, as has been shown, it is usually to be expected to occur —its nuggets may be compared to tubercles in an imperfectly organised lung which the labours of the digger bring into a state of active disease. Let it be confessed, then, that the author, though he be a believer in transmutation, is not an orthodox alchemist.

He would rather relieve his own mind and that of the reader from further details of this kind by recurring, in a few words, to the ground that has been gone over, and thus complete the sheet for the printer.

In the preceding pages the author, postulating material elements of one kind only—not sixty or seventy different kinds, as in the popular chemistry, and a single law of molecular action—not an undefined number of such laws as is usually done, has been guided by the manipulation of these duplicate units by that single law, to the construction of an unavoidable or truly synthetic and perfectly definite molecular system.

Whether that system thus necessitated by method should represent the material system or nature remained to be seen; for it was and is a pure construction developing itself from within itself on its on principles. Yet let it not be said that, being such, it sets at defiance the only method which is tolerated in science ever since the days of Bacon. In its details it was indeed effected purely by a process of *synthesis a priori*. But the conceptions, both of the material element itself and of the law of synthesis, claim to be ultimate generalisations from observation, or obtained empyrically in the first instance. If the author has preferred to rest them upon a basis of reason rather than on the external senses, this was done only because, in order to mental satisfaction in any pursuit, reason must be satisfied, and because it is certain that observation by the senses, when rightly interpreted, is always in harmony with the demands of reason. Let it be confessed also, that the author, during all the successive movements of the construction, had facts and phenomena in his eye, and generally avoided investigations which could not be verified in this way. Subsequently to the time—now nearly forty years ago—when he commenced his synthesis, many verifications have been obtained which did not then exist, especially of late, when the unfitness of the common eyesight for analytical purposes has been remedied to such a considerable extent by the use of the prism. If the various elements, which have of late been ascertained in this way as existing in connection with the sun and stars, be compared with our elements, they will be found to be precisely those which our theory would lead us to expect in such situations.

How long it may be before men of science will think it worth their while to master the details given in this and the two preceding Parts remains to be seen. The author, when he considers how difficult he has found it, and still finds it himself, to believe that such insight into nature as his views imply is possible to be attained, is not so unreasonable as to expect that others will soon regard them even as probable, much less as proved. Meantime, he is content with the private enjoyment which these views impart to himself, especially as that enjoyment is not merely the gratification of a chemical curiosity, but attaches to a much larger field of thought. No doubt he desires that others should share that enjoyment immediately. But, plainly, he cannot do more than render it ultimately possible.

One of the points to which he now refers as possessing great value to his own mind, is the place which his investigation assigns to material nature in the universe of being. It is much the fashion in the present day to regard matter and force, more shortly matter, as all in all. But, according to the view of things which has presented itself to the author and is here advocated, matter comes out rather as a precipitate in the universal æther determined by a mathematical necessity, a grand and beautiful cloud-work in the realm of light, bounded on both sides by a world of spirits; on the upper and anterior side by the great Creator himself and the hierarchy of spirits to which He awarded immediate existence, and on the lower and posterior side by that world of spirits of which the material economy is itself the mother and nurse. The hypothesis that there are no beings in the universe but those which possess a molecular structure, and that sensibility and intelligence take their first beginnings in such structures, nay, attach to one kind only of such structures—a kind which there is no ground for believing to be capable of construction or of existence anywhere in the whole universe, except in this comparatively insignificant planet, is one of the most inadequate conceptions that was ever proposed for scientific belief.

Another result of his researches, which the author contemplates with much satisfaction, is the evidence which they supply for the thought that existence has been awarded to the finite for the sake of multiplying enjoyment and intelligence. So long as One only existed, one only could know and enjoy. But by awarding existence to a creation, all but an infinite number may. Nor is it any argument against this view that the partitionment of being has been carried so far that the minima naturæ are too attenuated to be capable of knowing and feeling, that is, of mirroring the universe in themselves, and of enjoying the spectacle. Granting our cosmical law (that the creation shall assimilate in its properties as far as possible to the Creator in his attributes, that is, manifest Him) this result has been shown to be inevitable (see Part I. Chap. VII.) Besides, who can tell how much these minima contribute to knowledge and enjoyment, constituting as they do the elements of the medium of light?

But this view will be opposed on its very mention by the remark, that throughout all nature the dead transcends the living immensely in quantity. If nature, it will be said, be really the work of an ever-living One, to whom life and happiness cannot but be primary objects of regard, what we should expect is this, that the first objects of creation should manifest life, and that life should be paramount; instead of which, is it not obvious that the quantity of the dead is immense compared with that of the living? So it will be said. But is not evidence appearing year after year which calls more and more loudly every day for a correction of such a view? Who could have believed, who would have dreamt, even a year or two ago, that the lowest and darkest depths of the ocean which can be reached are teeming, and, in fact, carpeted with living creatures wherever the temperature does not forbid, just as the sunlit meadows and hill sides are with plants and flowers, and the multitudinous tribes of animated beings that feed upon them? And do not all the most recent microscopic researches go to show that the atmosphere in like manner is full of life, and, in a word, that in every region there is nothing so difficult as to prevent the apparition of living creatures wherever there is a medium that is capable of maintaining animal life. Nay, what expression so familiar or so high in favour with men of science at this moment as "the struggle for life." That expression has indeed been so shaped as to associate the idea of suffering and evil with life, instead of enjoyment and good. But still it witnesses unequivocably to the fact that life tends on all hands to press beyond the limits of its possible existence. And that it should continue to do so age after age can only be explained on the supposition that there is at least more good than evil, more enjoyment than suffering, in it.

But why, it will be said, if our view be sound, why should there be anything that is dead in the universe at all? To this the answer is, that there is nothing dead except within the material sphere. And there, if deadness is determined to a certain extent, it is so by conditions which to all appearance even Omnipotence cannot overpass. The *Divine Intelligence*, when bearing upon such objects as the material elements, or, in other words, *Applied Mathematics*, determines, that only a few of the many molecules which must result can possess such quickness, such internal mobility and polymorphism as are required in structures which are to be the instruments of sensibility and intelligence. Of these molecules, by far the greater number must be far too stable or immobile for any such purpose. Deadness in material nature is therefore unavoidable. But to the very extent that molecular structures are dead or stable, they are suitable for forming a stage on which life may play. Not without a valuable use therefore to the living, and therefore not without a sanction in reference to a fully animated creation, is that which is stable or dead, while, at the same time, so far as can be seen, it is unavoidable in a purely mechanical system.

In a word, this theory of the material system as a theatre for life is justified if it appear that those molecular structures which are first given to nature where molecular synthesis is going on in the most perfect manner, are also the most animated and mobile, and suitable for constructing the bodies of sentient creatures, while those which are stable and dead, but unavoidable, are of later date, and as it were incidental, and when they appear are turned to account for the benefit of the living. Now this is precisely what we have found (though at the date of the finding I was not in possession of the view of nature which I am now insisting upon). We have found that when material elements existed free in the celestial spaces, each invested with its full complement of ætherial atmosphere, that is, in circumstances most favourable for a most perfect synthesis into the most perfect molecules, they had been so framed at first as to give to nature first of all hydrogen, followed by common and then by ammoniacal vapour, and thereafter by carbon and phosphorus—in a word, those very elements which most properly receive the name of organic. Nay, further, we found that the very first phenomena of the condensation of vapour, the primal weaving of the clouds of the first morning in the sky, was a preluding in structure and a preparation for organic tissue (see p. 95).

It was afterwards, in the abyss, where the material elements existed under greatest pressure, most closely packed together, and with the æther proper to each most nearly extruded from them, that we found that the mineral elements were being formed—those elements which, comparatively speaking, may be regarded as dead.

Great violence, then, is done to the order of nature and to the cause of true science when the attention of the student is principally directed to the mineral elements, and organic chemistry is thrown into the position of an appendix.

It is for the sake of life that everything exists in nature, and so it ought to be in science.

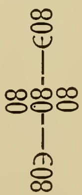
Postcript.

Better diagrams of hydrocarbons, &c., than those given in Chaps. VIII. and IX. may be constructed by a still nicer manipulation of existing types.

Flesh.

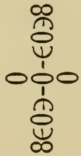
$C_8H_6NO_3$
(See p. 99.)

Inosic Acid.



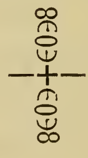
$C_5H_3NO_5$
(Monobasic.)

An Element of Uric Acid.



$C_5HN_2O_2$
(Monobasic.)

Urea.



$C_2H_4N_2O_2$
(See p. 101.)

Bicarbonate of Ammonia.

$C_2H_5NO_6$
(See p. 96.)

INDEX.

The Roman numerals iii. ii. i. *refer to Parts Third, Second, and First. The common numerals to the pages in these Parts respectively.*

EXPLANATION OF THE PLATES.

Plate I.—If the material universe be taken as consisting of separate elements of physical force, matter, or units of weight, all of them being similar to each other, then, these elements or units, on being subjected to a law of synthesis, on the principle of order or symmetry (which is found both mathematically and experimentally to be that of statical equilibrium among equal and similar forces) give as their earliest constructions such molecules as are here (very imperfectly) represented (the white points indicating the centres of the elemental forces, the white lines between them the ultimate resultants in these directions of their reciprocally attractive and repulsive energies, and the black region around these nuclei the nearest portions of their ætherial atmospheres or dynamospheres).

There is first given the tetrad, fig. I. (see J. Boscovich, Theoria, Phil. Nat. p. ii. § 239). This tetrad forthwith improves its condition as a mobile or separable element, either (1) by doubling into the bitetrad (or hylagen), fig. II.; or (2), by taking another unit of weight into union along with itself, as in fig. III. (hydrogen). And by the aggregation of one or other of these two, or of both together, in numbers determined by their own forms (atomicity) and by the law of symmetry, elements representing all those which are treated of in chemistry may be constructed.

One of fig. III. has five points suitable for the attachment of some other element. When to each of these five one of fig. II. is attached, and the resulting combination has settled into its form of greatest symmetry, there results fig. XI. Its weight is $\mathrm{H} + 5\,\underset{\circ}{\mathrm{H}} = 5 + 5 \times 8 = 5 + 40 \div 1 + 8 = 9$. Now this is the weight of an unit volume of common vapour when an unit volume of H is unity! Its form is also hexagonal, and thus it explains the most characteristic natural phenomena of the aqueous element. But it is dimorphous; and hence it explains the characteristic and very varied chemical phenomena of moisture. Thus, when called upon to enter into union with an element of the pentagonal series of forms, such as figs. IV. or V. (to which, being itself hexagonal, it is unconformable), it can assume the form of fig. XII. Now fig. XII. answers completely to the chemical conception of HO, and may possibly be insulable as its double H©H (for this is symmetrical), that is, in ordinary chemical symbols, as H_2O, in which the unit volume of O is 16 when that of H = 1. Moreover, each of these two forms of the aqueous element tends to develope the other, giving often in nature a combination of both, the resultant lines of which are given in fig. XV. Pl. II., introducing organic molecules.

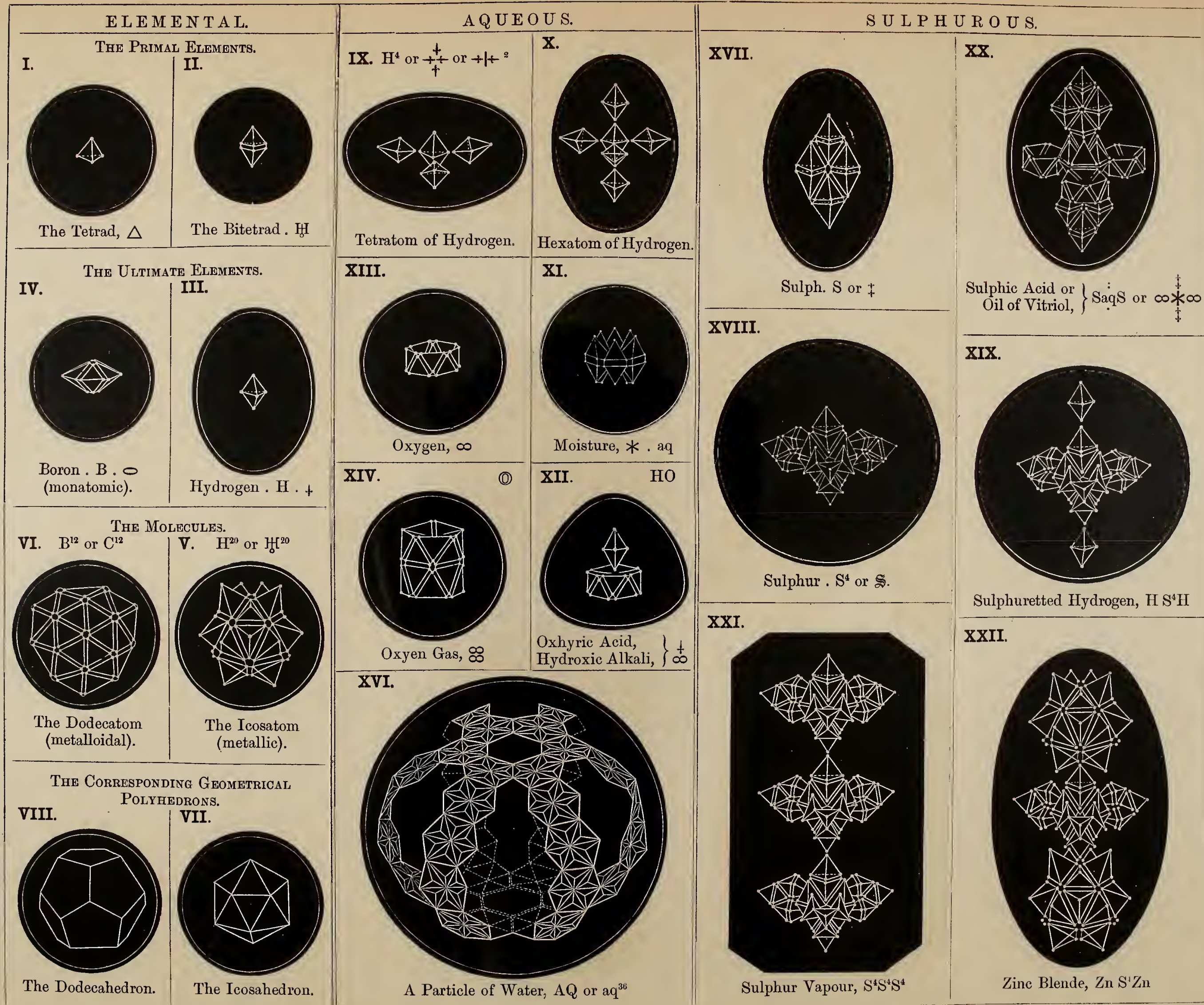
But five doubled tetrads (fig. II.) may unite symmetrically not only by their facets, thus generating oxygen, but by their edges also, thus generating sulph (fig. XVII), and its tetratom sulphur, &c. (figs. XVIII., &c.), also ultimately some metals (fig. V.)

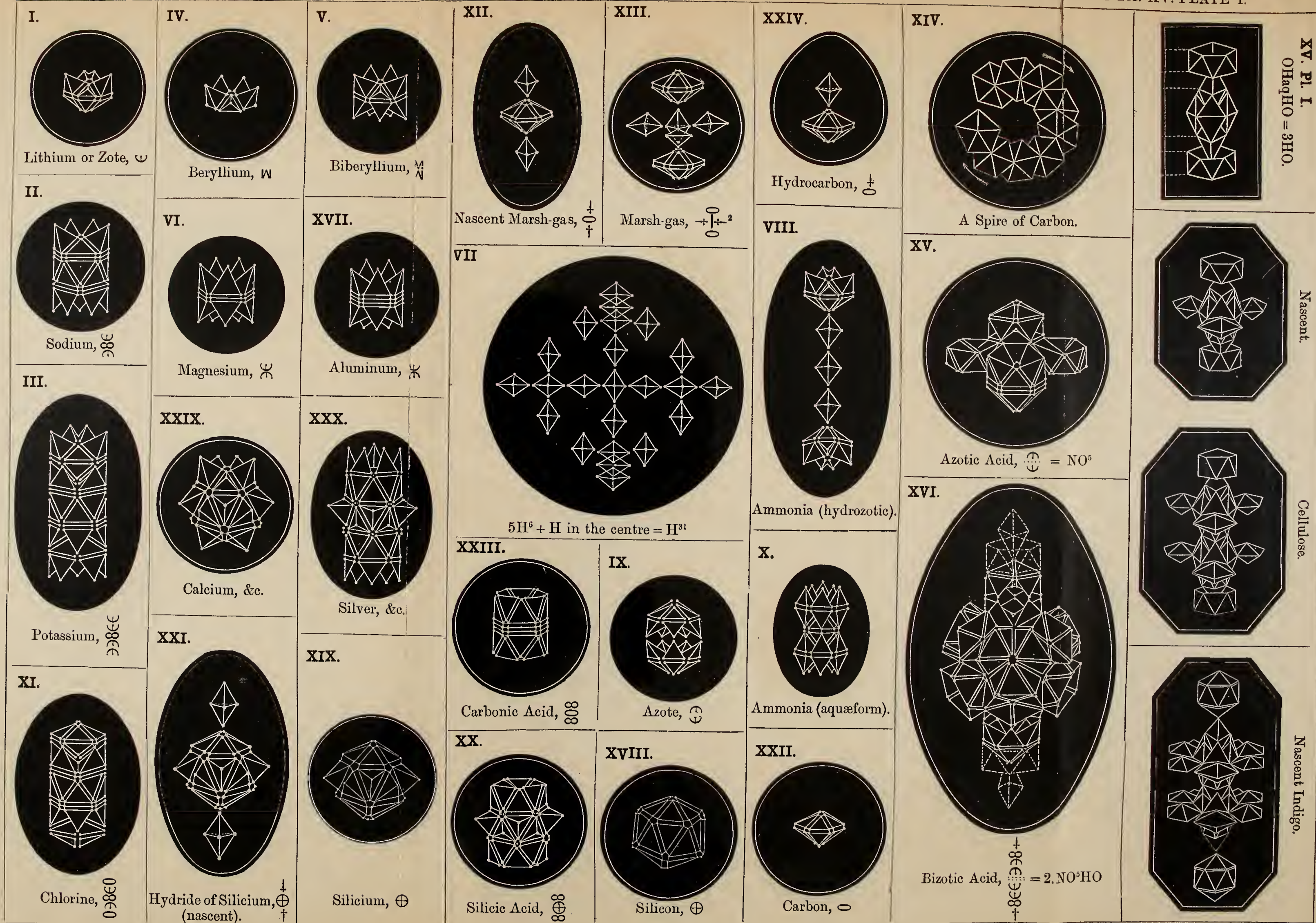
Plate II.—Bitetrads, in sets of five, may also unite otherwise than poles to equators, by their facets or by their edges, as described. They may unite so that a homologous edge in each may be a common axis of the combination, fig. I. (lithhium). But this structure is dissymmetrical both in its axis and in its outward form. It is therefore uninsulable by itself. But the polar regions of the atom of oxygen are perfect moulds for it, or coupling joints for two or four. Hence of this dissymmetrical element, one or more, may be insulated along with oxygen, and separated as undecomposable suboxides, single or double, figs. II. and III. (sodhium, potashium).

In consequence of its double dissymmetry, however, it must be secularly subject to a twofold reduction, emitting one, and ultimatly two, atoms of hydrogen, and losing weight proportional. In the first instance it establishes symmetry of axis, but retains its external (semi-metallic) form, fig. I.; its atomic weight 7 when H = 1 (lithium). In the second instance it recovers external symmetry also, but with loss of the 5-fid or metallic pole, fig. XVII., its atomic weight now reduced to 6 when H = 1 (carbon). But both the unreduced and the fully reduced may be combined, as in fig. XI. (chlorine).

The three last figures in this plate, when compared with the three in the middle at the top, may be taken to illustrate the difference between the true organic products of vital action, commonly so considered, and those which are merely chemical. In merely chemical products carbon-and-hydrogen-forms are only united by their poles (see figs. XII., XIII., XXIV.). In truly organic products they are united by their equators (see nascent cellulose, indigo, &c.).

PLATE I.


ELEMENTAL.
The Primal Elements.
I.
The Tetrad, △
II.
The Bitetrad . Ħ
The Ultimate Elements.
IV.
Boron . B . ⬭
(monatomic).
III.
Hydrogen . H . +
The Molecules.
VI. B^{12} or C^{12}
The Dodecatom
(metalloidal).
V. H^{20} or $Ħ^{20}$
The Icosatom
(metallic).
The Corresponding Geometrical Polyhedrons.
VIII.
The Dodecahedron.
VII.
The Icosahedron.
AQUEOUS.
IX. H^4 or
Tetratom of Hydrogen.
X.
Hexatom of Hydrogen.
XIII.
Oxygen, ∞
XI.
Moisture, ✳ . aq
XIV.
Oxyen Gas, 8
XII. HO
Oxhyric Acid, Hydroxic Alkali,
XVI.
A Particle of Water, AQ or aq^{36}
SULPHUROUS.
XVII.
Sulph. S or ‡
XX.
Sulphic Acid or Oil of Vitriol, } SaqS or
XVIII.
Sulphur . S^4 or $.
XIX.
Sulphuretted Hydrogen, H S^4H
XXI.
Sulphur Vapour, $S^4S^4S^4$
XXII.
Zinc Blende, Zn S^4Zn


I.
Lithium or Zote,
II.
Sodium,
III.
Potassium,
XI.
Chlorine,
IV.
Beryllium,
VI.
Magnesium,
XXIX.
Calcium, &c.
XXI.
Hydride of Silicium,
(nascent).
V.
Biberyllium,
XVII.
Aluminum,
XXX.
Silver, &c.
XIX.
Silicium,
XII.
Nascent Marsh-gas,
XIII.
Marsh-gas,
VII
5H⁶ + H in the centre = H³¹
XXIII.
Carbonic Acid,
IX.
Azote,
XX.
Silicic Acid,
XVIII.
Silicon,
XXIV.
Hydrocarbon,
VIII.
Ammonia (hydrozotic).
X.
Ammonia (aquæform).
XXII.
Carbon,
XIV.
A Spire of Carbon.
XV.
Azotic Acid, = NO⁵
XVI.
Bizotic Acid, = 2.NO⁵HO
XV. Pl. I.
OHaqHO = 3HO.
Nascent.
Cellulose.
Nascent Indigo.

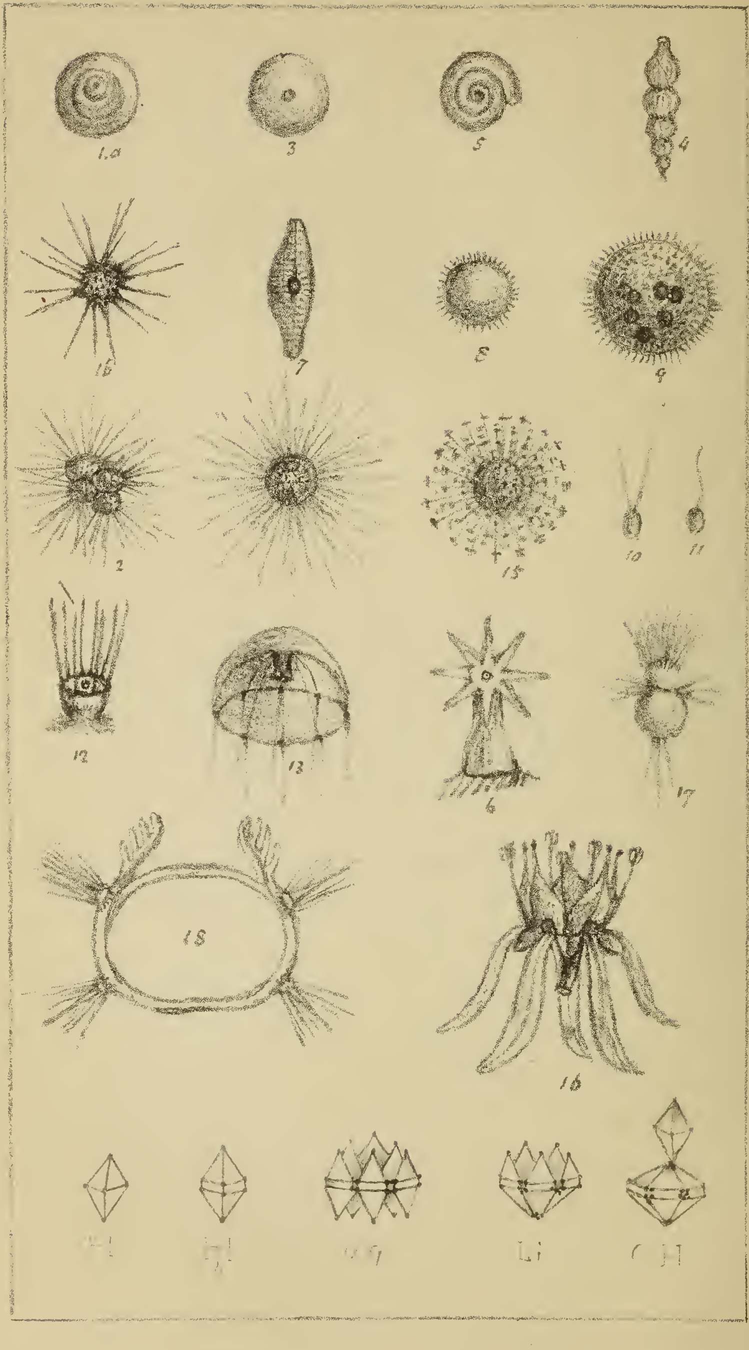
A SKETCH

OF A

PHILOSOPHY.

Ἄριστα ὦ Τίμαιε.

PLATON in Tim.


1.a
3
5
4
16
7
8
9
2
15
10
11
12
13
6
17
18
16

A SKETCH

OF A

PHILOSOPHY

PART IV.

BIOLOGY AND THEODICY

A PRELUDE TO

THE BIOLOGY OF THE FUTURE.

ILLUSTRATED BY A PLATE AND DIAGRAMS IN THE TEXT.

BY

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PREFACE.

In this concluding Part of "A Sketch of a Philosophy" (and in the preceding Parts no less), the views commonly held on the same subjects have scarcely ever been placed in contrast with those which are here advanced, or the evidence in favour of either balanced. Our philosophy has been presented to the reader mainly as a cycle of thought, arising out of an unity, given by consciousness as a reality, which developes into variety, and which as it flows is met in its course by Nature verifying it on all hands in actual phenomena. With these phenomena the reader is supposed to be well acquainted, so as to be able on his own suggestion to connect together our deduction or development with the corresponding phenomenon as a verification. For the author to have gone on verifying as he proceeded would have required many volumes, and such an interruption of investigation as would have made it impossible to accomplish what he believes that he has accomplished.

If it be asked what this is, the answer is, that the student of science by admitting three fundamental ideas—(1.) An Infinite and Perfect Being the fountain of all; (2.) finite Being, His creation, and as it were His shadow, given by His breath in space and time; and (3.) the Law of Assimilation, the cosmical law, the sole law of nature, whether matter or spirit—the student in science—may save himself the time and trouble of acquiring a vast number of technicalities and formulæ, and much besides that commonly goes by the name of science, and proceed at once to explain in a manner satisfactory to himself, if he be free from bias due to antecedent training, the most part of what he reads about or observes around him—provided his observation or narrative be accurate, and in any measure proportional in quantity to the whole of what he proposes to explain.

And here the possibility of much saving and success may perhaps be made to appear probable even in a few words, by stating in immediate contrast the general features of the science of the day, so manifold and often so conflicting, with the few principles which are insisted on in this and in the three preceding Parts.

I. Instead of postulating many kinds of natural substances essentially different from each other, such as spirit, and æther, and matter of some sixty-three different kinds, each kind with its own essential properties, our philosophy postulates only one kind of finite substance, and that with no intrinsic properties at all, but finitude as to quantity, and self-manifesting power, that is, existence, using the term philologically.

II. Instead of attempting to explain the phenomena of the intellectual, the moral, and the material universe, on the supposition that the original ground of all is dead matter and force, or force alone so mechanically constituted, that its mode of action may be defined in a mathematical formula—a basis for investigation by which the highest and most important phenomena of all, those of intelligence namely, can be even recognised surreptitiously only, and can be accounted for in no degree, and are therefore naturally thrown into the background and disparaged, while yet they are plainly the most obtrusive of all phenomena, and indeed constitute that realm in which all philosophy and science, and in which alone any philosophy and science can be pursued—we open our lines in this very field of intelligence in which we find ourselves at first, and in the light of which we are inexorably required to view all things from first to last; and invoking from the depths of our own consciousness the affirmation of intelligence in perfection somewhere else than in ourselves, we posit as the first word and principle of our philosophy, a Perfect an Infinite Being, possessing without limitation or defect those attributes which our intellectual and moral nature mirrors in an imperfect degree. Thus finding that at the fountain-head all is life and reason, we escape the hopeless inquiry which is now agitated with such conflicting evidence and argument, as to where and how the living begins to appear among the dead, and why nature manifests reason everywhere.

III. Instead of a continually increasing crowd of so-called laws of nature, rational or empirical, it follows from what has been stated that but one law is to be expected for the whole universe; and this we maintain. For how could the finite substance of creation be actuated otherwise than so as to embody and to body forth the will, that is, the activity of the being and attributes of the Creator, so far as the finite can embody and manifest the Infinite. The finite, considering that it lives and moves and has its being in the Infinite, which is Infinite Power, surely cannot but assimilate itself as far as possible to the Infinite, and manifest in itself His being and attributes. The mere substance of creation, viewed as apart from the Creator, must be wholly amorphous, so to speak, and passive—wholly plastic and assimilative. Hence the law and economy of the cosmos must be Assimilation both subjective and objective.

Let it not be thought that if such be the only law both for spirit and body and all things, there must have resulted in creation universal sameness, long before the present epoch, if not from the very first. No; by assimilation to the Creative Will, *spirit* comes to be possessed of a measure of individualised power and liberty, which maintains variety and difference in the spiritual sphere; and *body*, having to exist in space and time, that is, in positions and moments presenting essential and endless differences, there results, along with a discoverable tendency to similarity everywhere, such a variety as nature actually displays, and the universe is, as we find it to be, a cosmos or harmony.

Of this cosmical law—the law of assimilation—some of the most immediate results are these:—

(*a.*) In virtue of the omnipresence and imminence everywhere along with unity everywhere of the Infinite, there result *in the finite mind* the two grand processes of distribution or analysis and association or synthesis by which all logical thought is at once developed and regulated (and that of course by the law of assimilation); and *in the finite substance generally* there arise the properties of divisibility and confluence.

(*b.*) In virtue of the spirit-nature of the Infinite, the first-born of creation is a world of spirits. And this world, for the reason assigned in the last paragraph, is a hierarchy, which, being first constituted in fulness of attribute, afterwards, under diffusive or analytic agency, descends, expands, and (being finite) attenuates, until, simulating omnipresence, it vanishes into the universal æther or realm of light, thus providing for its inhabitants a congenial dwelling-place and home.

(*c.*) But why, it may be asked, are not the elements of the finite substance, which is essentially spiritual, after having been attenuated into the ætherial, not confluent into monads possessing mental powers again as fast as they are reduced to minima, so that an abode having been once provided in the realm of light for the world of spirits, the whole creation may consist of sentient beings only, and the sustained voice of the universe be universal enjoyment? To this the answer is, that in virtue of the self-assimilative, and therefore self-conservative, power of the ætherial elements, synthesis or aggregation can only take place by juxtaposition and not by confluence, until the nebular speck resulting has attained a certain bigness and pressure towards its centre. And when this bigness has been reached, and confluence in the centre does take place, the monad resulting is still too feeble to have recovered mental powers, and can only manifest such mechanical powers that, taken along with its generating atmosphere of æther, this new order of being, this new unity, constitutes the material element.

(*d.*) But though the immediate and direct birth of spirits out of æther or the matter of light in which the spirit-world dwells, be thus prevented by the genesis of matter instead, yet the restoration to the spirit-world of all the substance beyond, the overflow in æther, is not frustrated. The synthetic action which gives to nature the material element, goes on in the matter generated until a scaffolding (in our planet the myo-cerebral apparatus) is erected by which such a large and powerful volume of unified organised æther is upheld for years, that there is given by confluence in its focus of action a monad, constituted by such quantity and energy of substance or force (which are the same) that psychical, ultimately as in man, spirit-power is restored; in fine, there is a spirit adequate even to mirror the attributes of the Infinite, while the mode of its birth and education secures its being in harmony with the material economy, as long as the organism is its home.

Thus the created substance, after a lapse to a certain extent into matter, that is, into the apathetic and the dead, is raised to life or spirit again, and becomes capable of new enjoyments, in aspiring towards the ever-blessed One, the author of all.

Our philosophy thus retains all the facilities of materialism and pantheism in explaining phenomena, and contains within itself the theory of evolution. But it accuses these views of a want of extent co-ordinate with that of reality, and affirms that a philosophy adequate to satisfy reason must have as its first word an Infinite Omnipresent Intelligent Being.

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POSTSCRIPT.

This sketch of a Philosophy is now brought to a close, and that not without pleasing prospects as to the future of Science. Since 1868, when PART II., which related to molecular construction, was printed in Germany, there has been a notable progress of philosophy in the same direction. The spectrum-analysis of star-light emanating from sources differing greatly as to the degree of heat which actuates them, or the state of diffusion and attenuation in the matter of which they consist, has forced on the minds of chemists the very reasonable suspicion that cosmical force, acting out in the great universe since the beginning of time on the same particles of matter, may be capable of doing something more in the way of ultimate analysis than the chemist in his laboratory with his small experiments. In consideration of the growing simplicity which seems to characterise the light-giving elements of different heavenly bodies according as they are on the way to greater attenuation through heat or are already extremely attenuated, the idea begins to be tolerated even by experimental chemists, that of the 63 so-called simple substances only a very few, perhaps only one, can survive without decomposition that ordeal of molecular transformation which is the very secret of all the variety, the harmony, the beauty of nature.

On comparing the data of the spectroscope with our molecular synthesis, it will be seen that those substances which ocular vision gives the astronomer as the last survivors under extreme cosmical analysis are the same as those which mental vision has given us under our method as the most simple, stable, and recurrent of molecular structures, viz., two lighter than hydrogen, hydrogen, nitrogen or azote (which in our theory is secularly resolvable into hydro-carbon ; $2\ Az = C_4H_4 =$ olefiant gas), magnesium, sodium, iron, &c.

Chemists are still indeed content with their formless, structureless, phantom-atoms, instead of particles looking like reality, having distinctly conceived forms and structures ; they are content with mere abstractions, such as atomicity and affinity, instead of well-understood reasons and mechanical causes ! But surely chemistry as it now exists must soon become tired of itself. Surely it cannot be long before earnest minds who have youth and energy will make a rush into the light. As to others, it must not be forgotten that death usually supervenes before even demonstration can wholly change a long-cherished habit of thought. It was more than a generation—upwards of 30 years—after the publication of "The Principia," before the philosophy of Newton was presented to the University of Cambridge, and even then by stealth, under the protection of the philosophy of Des Cartes, which was still taught ! Moreover, the perpetual secretary of The Academy of Science in Paris, living in scientific communication with all the world, 58 years a member of that academy and its historian, a man of genius, and an admirer of Newton, 70 years after the publication of "The Principia," still maintained the Cartesian astronomy, and died in that belief, though he lived to his hundredth year ! Happy the man who by his own researches has been able to satisfy the demands of his own reason and to make silence in his own heart.

CHAPTER I.

BIOLOGY: ITS RELATION TO THEODICY.

A VERY remarkable change has in these modern times come over the study of nature. Formerly, nature used to be regarded chiefly in a contemplative point of view. Its grandest and most striking objects and arrangements were alone observed; and as in them either beauty or utility, or both, were conspicuous, the thoughts of the beholder naturally turned to the Author of nature, and tended to close in a spirit of adoration.

But now all this is changed. The characteristic of our times is minute research. To see all that can be seen about some one individual object in hand as also about those which are most nearly allied to it, an accurate comparative crystallography or chemistry or anatomy of the object in the successive stages of its existence, and that specially, nay merely, in order to be able to classify it or to assign to it its "place in nature," is at present the main aim of the naturalist.

And, in this minute research so much is encountered that seems at first sight to ignore, nay, to conflict with the useful and the beneficial, that contemplation, when it is ventured upon, is often felt to be rather painful than agreeable; and many naturalists of high intellectual powers, and not of an irreverent turn of mind, have given up adoration as an untenable position, and even orthodox divines have maintained that it is only from revelation, and not from nature, that any true knowledge of the Deity can be obtained.

Now, viewing this change in its general bearing, both on the man of science and on society at large, unless there be some great gain to balance it, plainly there is great loss. Yes; setting aside all other considerations but that of personal enjoyment merely, and on the most restricted view that has ever been taken as to that which really exists,—adopting as to this matter, for instance, what the fashionable method of investigation logically leads to (which has been happily stated, without reserve, by J. S. Mills, in his criticism of Sir William Hamilton's philosophy), namely, that all we are certain of by way of external universe, is "a possibility of sensations," and by way of soul or mind, "a thread of consciousness aware of itself;" even supposing this to be all, still it remains true that the old contemplative way of viewing nature in the spontaneous and uncritical light of common sense had much in its favour which is lost in this new way. For of all "threads of consciousness," certainly there is none that is at once so delightful and so ennobling as adoration when there is seen by the contemplative mind to be a just occasion for it; and if, taking a larger view, we admit (what always has been, and still is, generally believed) that man, along with a regard to his own present enjoyments, has certain duties to the Author of his being, on the right discharge of which his true happiness, both here and hereafter, mainly depends, then, for him to live a stranger to adoration, which is manifestly the first of these duties, can be no light matter.

But it will be said, and said justly, that the teaching of the truth must be submitted to, whatever it may be—that the truth must be followed whithersoever it may lead. If the minute and accurate study of nature, it will be said, fails to suggest, and especially if it forbid the suggestion of an object of adoration, then we must exclude from our study such an object, and, of course, the emotion also which is appropriate to it, whatever the disadvantages. At any rate, we must look for the evidence for the existence of an object of adoration somewhere else than in nature. Now, let all this be admitted. But it has not come to this, nor anything like this. It may be shown, and shown most satisfactorily, viewing nature, both on its grandest scale and in all its details, that there is nothing in it to contradict, but everything to countenance and support that world-old view which regards nature as the creation of an infinitely perfect and powerful Being; only, to be able to co-ordinate nature with this view requires something more than the quick eye and the lithe fingers which are alone demanded by minute anatomy. It requires a habit of thought which aims at being all-embracing, and, along with an acquaintance with particular objects, a comprehension of all.

There is no legitimate occasion for giving up the old point of view, or, in order to find information on Physico-theology, to have recourse to the book-shelf. On the contrary, now for the first time, and that simply because of the most recent advances in science, has it become possible to account for the evil in nature, without hurting the spirit of adoration; while as to the good, it meets the eye as fast as ever, and proclaims as loudly as ever the goodness of the great Creator.

As to biology, the science of living beings and things, which is, of all the branches of science, at once the most interesting and the most important (for it points continually to the knowledge of self), valuable progress has of late years been made in it. The rationale can now be given of not a few important biological facts, which have indeed been long known as facts, but which have never till of late been rightly understood. But, meantime, many more have been presenting themselves, the reason of which still remains unknown. And the confession must be made at the same time, that the more extended observation which has been taking place, has been increasing our consciousness of ignorance at a much faster rate than our knowledge.

Among those which are now well understood, however, some are very important, and their theory very interesting. Thus, since the earliest times, it has been known that, in order to be kept in life, an animal must continue to breathe and to receive nourishment; and it was easy to understand, and it was understood long ago, how certain creatures (a herbivorous animal, for instance) whose food was such that it could not all be converted into the substance of its body, must needs get rid of the unsuitable particles of its food by breathing or otherwise. But it was not understood till lately why an animal that fed on other animals, the composition of whose bodies was the same as its own, should be also dependent every moment upon respiration, which was nevertheless seen to be the fact (for the carnivorous lion or tiger cannot live one minute without using its lungs, any more than the herbivorous ox or horse). To explain how it should be so, all that was possible, until lately, was to suppose that the muscular machinery of animals broke down in the using, simply through wear and tear, just like that machinery which is the work of men's hands, and, therefore, that the debris of their tissues had to be got rid of and carried out of the organism in some way or other; and thus the existence of lungs and kidneys was explained and justified. This theory also explained the necessity of alimentation at the same time, and altogether it seemed to be adequate. It postulated, however, that the great Creator both contrived and executed His designs in the same way as man does, and under similar limits as to defective workmanship. There was reason to suspect, therefore, that it was intrinsically defective. And now that view has spontaneously passed away. Since the revival in our day of the Leibnitzian doctrine of the conservation of energy in the material universe, it has been seen among other things, that inasmuch as every animal in all its motions is always putting forth energy, which is always passing from it into the ground, or into the air, or into whatever else gives the animal a purchase and a place in nature, so must that animal be always losing energy. And if it is to retain its strength, it must be provided with the means of continually drawing fresh energy from its environments. Now, of energy it is known that there is a store in the action of the oxygen of the atmosphere; and it is also known that this oxygen pours itself into the animal, as also, that when within the animal, it assails the carbon which was supplied in the food, and which, having been now exhausted by the work it has done, has become open to a successful attack by the oxygen; whence there is produced within the animal a regulated supply of heat. This heat could not have been obtained consistently with organisation, otherwise than by some process which previously exhausted and exposed the carbon within the organism; but this the exercise of the animal's activity does successfully. Thus while the life-engine is doing work, it is generating within itself heat proportional in amount to the work it does. Now, heat is the most elemental form of energy, and that which is available for the greatest number of purposes. It can no longer be said, therefore, that the break down of the muscular fibre under the work it does is a fault of the machinery, or in any sense an evil. On the contrary, it is a provision for the continued working of the engine. And thus respiration, instead of doing merely the work of a scavenger, as was long thought, does the work of a prime minister, the stomach being the commissariate, but nothing more, at least in the full-grown animal. The old theory, then, which implied a mechanical defect in the structure of the machinery of the active tissues, has vanished; our conception of the work of the Creator is exalted; and the whole conception is beautiful and satisfying to reason. And to this theory of respiration and alimentation, that of the circulation may be added, not only as being implied in the former, but as being well understood in its own details also.

It may, indeed, be said that by this change of view, the charge of defect in the muscular system of animals is not avoided, but only shifted from that of defective mechanism to that of vital exhaustion. Why, it may be argued, did not an Almighty Creator, if such there be, impart an adequate supply of energy to the tissue, to keep it fit for work as long as it could last as machinery, in spite of all that it might give off to surrounding objects? Now, this is just one of those questionings which, though at first sight they may seem reasonable enough, yet, when looked into, are seen to be without justification. To ask for the supply of energy to mechanism at this rate is, in fact, to ask that there shall be no such thing as mechanism at all, or rather, indeed, no such thing as a creation at all; for a machine which possessed within itself an inexhaustive store of energy would be a machine which could create energy,—would be, not a machine, nay, not a creature, but a creator.

Here, then, is an instance, and there are many others in which good progress in biology of late may be reported. But it is no less true, at the same time, that the number of problems which have emerged, and which still remain unsolved, has been increasing in a much higher ratio.

It is seen, for instance, that an amœba (seemingly nothing better than a little bit of animated glue) can extemporise a stomach for itself, and accomplish a complete assimilation of its food; a protist creature, a mere structureless speck of protoplasm, can do that which we ourselves cannot do without a special stomach, a large liver, a pancreas, an elaborately convoluted intestine, &c., &c., and too often do it badly after all. Hence the problem, what the necessity, what the reason for these various certainly indispensable, and yet seemingly needless, appendages of the central canal of certain animals?

Again, there are many minute creatures—insects, for instance—which, to judge from their actions, are as instinct with mind, and in some respects more so than man himself,—mind in man, by all that appears, being altogether dependent upon brain,—while in these minute creatures scarcely anything to call a brain can be detected at all! The questions that may be or that are actually put are, in fact, endless, and are increasing every day. Moreover, sometimes they are such that they lie at the very basis of biology, at the root of all subsequent thought, craving an answer in the mind of every enquirer.

Such, for instance, is the question whether life and living things may not make their apparition where they were never before, and never have been introduced, in certain solutions, for instance, sealed when very hot, and supposed to have merely chemical contents; or whether a spore, or ovum, or germ of some kind, itself the product of some living thing, must not have been first placed wherever life actually makes its appearance? This question is plainly capital in biology. But the most eminent students answer it in quite opposite ways. Nor does science obtain any consolation, save in the invention of learned terms, formulating the speculation, as that, for instance, of "biogenesis" or "abiogenesis." The ancients never doubted that putrefaction gave birth to living creatures, and was all the parentage they needed. The moderns, having analysed the careless observations of the ancients, and found that, not only in the cases they counted upon as proving this equivocal generation, ova had been laid by living creatures, similar to those which presented themselves in the putrefying substances, but that all, or almost all living creatures produce ova, capable of developing into creatures like themselves, voted almost if not altogether unanimously against the ancient view. But now the wave of belief is tending again to the old shore. All the experiments of a Pasteur and others, seemingly so exclusive of the ancient belief, and in favour of the modern "*ex ovo omnia*," have not been able to prevent a Pouchet and others from bringing forward other experiments of a contrary bearing, while a Haeckel admits that experiments have not proved it, but that, doubtless, originally living arose from dead matter.

Similarly also, Huxley, sanctioning the method of experiment, and, like Haeckel, halving the difference, gives it as his opinion that, so far as experiments have been rigidly made and rightly interpreted, there is nothing to contradict the adage of "*omne vivum ex ovo*," but that, for his own part, had he been present at the beginning of life, he would have expected to see protoplasm making its appearance among dead matter. He, therefore, contents himself with a conclusion which his accepted method of investigation does not sanction, and leaves us only his candour to admire.

Now what, may we not ask in passing, can be the cause of all this conflict among men of science as to the origin of life? Is it not explained by the narrowness of the current conception of life, and the lowness of the point of view? The biologists of the present day never think of anything else but of seeking the living among the dead. Contrary to all reason, to all observation where the contact between the two is certain, they take for granted that death is antecedent to life. But is not the fact the very reverse of this? Of that fact is not "*omne vivum ex ovo*" a far too limited expression? Does not that fact, in its full extent, require rather the words "*ex vivo omnia?*" Yes; at the fountain head is not all life? Is not He who is there emphatically He who liveth for ever? And, having due regard to the kindred relationship that there always is between a cause and its immediate effect, is not that which we are reasonably to look for this,—that all nature, in proportion as it is protistic or lies near to the ever-living One, shall be found to be teeming with life? Let us not wonder, then, at the great embarrassment of men of science, so long as their thoughts never rise higher than to seek the living among the dead. But neither let us, on the other hand, manifest any sympathy with those quasi-theologically disposed persons, who seem to think that plants, and especially animals, alone require a Creator, while as to the crystalline world, and, indeed, all nature besides, it may go about its business, and be left in a merely aboriginal or atheistical or even antitheistical state.

And here let me make a correction, or rather an addition, to the remarks that have been made already on the subject of respiration. In these remarks it was presumed, as is usually done, that the only new source of energy obtained by breathing comes from the incidence of oxygen on the organism, and that the whole cycle of the energising consists in phenomena which are purely chemical or mechanical, which in the last analysis are the same. I desire here to add (though under the disadvantage as yet, no doubt, of its seeming a mere hypothesis), that on tracing the relative phenomena to their very source, it comes out that respiration is preluded and exemplified, nay, we may say begun, by an agency on the sunbeam or the ætherial elements, which can impart power to these elements to supply what they impart to living nature, and consequently lose from themselves. Not that this Power, which is the first of things, and which presents itself to philosophy as lying beyond and above the sunbeam, is a property either of æther or of matter. It is Power in its very essence and fountain, possessed of all the highest attributes which are implied in the most complete idea of Power, and which Power is seen to possess anywhere. It is Power in perfection. It is, therefore, Power in unity, perfectly free or uncontrolled, perfectly perceptive or intelligent—in fine, possessing Personality. In a word, it is the omnipotent Author of all.

This is the first word of our philosophy. And hence there attaches to that philosophy the doctrine that, while the Author of all imparts power to those beings and things to which He has awarded existence statedly and harmoniously with their natures, so as to produce the vital, the dynamical, and mechanical phenomena of nature uniformly, He also stands in such relationship to all of them, as an Omnipotent Will holding them all in His hand, that by a procedure which may be justly called normal, that is, without any interference or miracle as commonly understood, He can empower or withhold power, in particular ways, forms, and cases, and so can order both individual life and cosmical phenomena as it may please Him.

To apprehend, therefore, as is often now done, and still more, to affirm, that human entreaty to the Deity for any physical change is necessarily impotent to obtain that change, and that even for a moral change such entreaty is nothing more than a mental discipline, is to entertain an apprehension, and to make an affirmation which is itself as unsound in science and philosophy as all mankind in all ages have shewn, by their prayers, that they feel it to be.

As to the denial, also, of the possibility, and consequently of the fact of miracle, that denial is valid only when nature has been so conceived and its course so defined as to exclude miracle according to a definition. Within the compass of such a definition, miracle is of course impossible, and there need be no inquiry about any historical miracle as to the evidence on which it rests. But such a conception of nature is not that of reality. It is not from the real world, but from an imaginary one, that miracle has been excluded in this way. As to reality, instead of its being near the truth to say that there never has been and never can be a miracle, it would be far nearer the truth to say that the whole course and economy of nature is one sustained miracle. That course, that economy does not excite popular wonder, indeed, because people are quite familiar with it and expect it, knowing that the same phenomena will recur when all the conditions of existence are the same. This phenomena surely must do, since their Author is at once perfect in intelligence, and perfect master of His material, and therefore is not liable to make any mistakes, or to introduce any corrections, or to determine otherwise from moment to moment or from age to age, than as he determined at first when the material economy was instituted and set agoing by Him.

And here I may make a remark upon the term "law," as now usually applied to nature. This uniformity of procedure which is implied in that of a perfect intelligence, is commonly taken, or rather mistaken, for the fulfilment of a law. One hears of little or nothing else in science now but of the laws of nature and of phenomena. And such language is not only convenient, but, perhaps, in consequence of the poverty of language, it is inevitable. Still it is only rhetorical. It is not strictly scientific. There is a great difference, in point of fact, between the fulfilment of a law, properly so called, and the recurrence of a phenomenon in the course of nature. A law, properly so called, is a formula or rule of action framed at some past time for the regulation of the time to come. It is a fixture which, having originated in the past, is handed down to be worked in the present by some executive power who shall know, accept, and obey it. Law, in fact, stands in contrast with autocracy, or a self-determining power acting, as such, from day to day. Now, of the two it is the latter which is most applicable to the course of nature and the production of phenomena. Not that there is necessarily any difference in the issue or products of either mode. Thus, let us suppose a living executive power or prince constituted with such hereditary perfection, that his instinctive judgments and proceedings upon them should be always the same as those of the laws of the land where he was brought up, then in that case everything in the state would proceed according to law, just as it had done before his day, though now without any reference to statute or any recognition of it. The entire regulation and life of society in such a case would be due to the activity of a living presiding will. And yet, those of the population who were acquainted with the statute-book could predict in every case what the forthcoming proceeding would be. But surely this uniformity and certainty, this power of prediction, would not detract from the recognition of the will and the power of the prince. On the contrary, in virtue of his transcendent ancestral and patriotic instincts, he would surely command the loyalty and homage of all. Now, for a perfect intellectual heredity, substitute a perfect intelligence, with perfect knowledge of the capacity of his subject atoms, and we have something like a conception of the mode of procedure in the production of the phenomena of nature. Nature cannot be said, except in a metaphorical way, to have been ordered long ago, and once for all to be as it is now and will be for ever. Nature is from age to age and from day to day the immediate expression of the ever-acting mind of the ever-living One, who, though not immanent in nature or one with it, is yet everywhere present to every atom in supreme power—able to modify or give birth to new phenomena to any extent, if He should elect to do so; in venturing to suppose which, however, plainly such ignorant and limited beings as we are should both think and speak with great reserve.

On this subject (in a small work published in 1855, and now no longer to be had) I have made the following remarks, with a view to show the harmony that there is between the expectation of the human mind and history on the one hand, and the course of nature on the other:*—"*An opening must be kept for possible miracles.*—There exists in the universe free power. Consciousness bears witness to it in self. And its existence either in self or anywhere it is impossible to explain, or to satisfy the demands of reason anyhow, without admitting that free power exists in perfection in Him who is the Author of all,—in whom it has just been seen that philosophy must find its last word, in so far as the study of phenomena is regarded as the study of laws. Now, of a free power the characteristic is to originate acts which may be both new and singular, and under no law but that of liberty. *Such acts, therefore, and phenomena expressive of them, we are to expect in the world, if the world be fully a manifestation of its Author.* Yet, this under two conditions:—*First,* we are to expect them sparingly: for if in His ordinary providence the Creator put forth His free power from day to day in accomplishing new and singular acts, there would be no place for wisdom in man; experience would only deceive; forethought would be folly; and all science would be impossible. Whilst, therefore, philosophy leads us to regard the occurrence of such new and singular acts of the free power of God, as necessary in order to render creation fully expressive of the Creator, it leads us also to expect them but rarely; and, therefore, to find them bearing some name expressive at once of their rarity and singularity, such as the term 'miracle,' which has now supplanted every other." It leads us also to expect them only in those points in which human nature comes into contact with physical nature, and in what we might call the singular points of the causes of social development and rectification.

* Elements of the Economy of Nature. A Fragment. Second Edition. Chapman and Hall, London, 1855, p. 2.

CHAPTER II.

THE PREVALENCE OF LIFE IN NATURE, PAST AND PRESENT.

Ordinary observation leads us but little to suspect the extent to which life exists now, and has existed in former ages, in our world. Compared with the amount of dead matter in the world, the number of living beings seems to be very small. And even to indulge, as an imagination, the thought that the crust of the earth can be to any considerable extent the product of the animated beings which have lived and died in our planet, seems very extravagant.

But when the naked eye is aided by the microscope, and due pains are taken to discover life wherever it may be now, or may have been in some former epoch, considerate and extensive observation leads to quite another view; and, indeed, makes it difficult to say where life may not have reigned in some former age, or may not even still exist.

Into whatever realm of nature we pry with the microscope, if only there be moisture in it and oxygen have access to it, then what is found is this, that the higher the power of the instrument, just so much the greater its revelations of life, animal or vegetable, just so much the more numerous the living beings or things that are seen in the field of the instrument.

As to water in general, though it may be such as to have been hitherto held to be pure, chemists and biologists give it as their opinion, that in order to be free from life, it must have been recently distilled; if not, it never fails, when analysed, to give indications of ammonia, which, as a product of the analysis of a natural medium or substance, is generally accepted as an evidence of the present or previous existence of living nature in the medium or mass subjected to analysis. And, indeed, without invoking the aid of chemical analysis or other means of discovery than the eye aided by the microscope, it is not easy to find any drop of water, which has stood exposed to the air for any length of time, which does not show itself to be teaming with living organisms.

It has also been demonstrated that the air is full of living things, as ova and spores, at least, if not as fully developed forms. There is, moreover, good reason for believing in the existence of the latter also in the air. It were strange and contrary to the analogy of nature—for nature is teeming with life wherever life is possible—that a medium should be capable of entertaining in it spores and ova in life for an indefinite time, and not be peopled with developing and fully developed organisms also. That they might be light enough to float in the air, and as fit every way for leading their lives in this medium as fishes are in the sea, there can be no doubt. And that they should be so small as to be invisible to the naked eye of man, is only what is to be expected; while with regard to the use of the microscope in this instance, it does not appear how it could be applied with a chance of success in catching them. Moreover, if caught, such is probably the delicacy of their organisation, that before they could be subjected to examination, they would most likely have been shrunk up so as to be mistaken for spores. In a word, nothing is so difficult as to find any region where man himself can live which is not occupied by other forms of life also. Nay, where man could not live a moment—where, till lately, it was believed that nothing could live, and that nought but eternal darkness and desolation reigned; in fine, the lowest depths of the ocean, like the sunny meadows and hill sides, are now found to be not merely teeming, but carpeted with living beings!

Nor is it only in quantity and diffusion that simple organisms everywhere abound, but also in exquisite symmetry and beauty. In comparison with many of them, everything among large animals seems slow and stolid, and often ugly. They are to large animals what lace-work is to matting. To be convinced of this, happily, it is not necessary to inspect them in the living state, which would be impossible for all but a few observers. Happily, an indefinite time after they may have died, one can study them at his leisure in the cabinet; for many of these beings, though so minute, have been endowed with the power of secreting, for their own protection while in life, a marbly or quartzy framework, which is very durable, and which, under the microscope, proves to be of exquisite beauty. And in consequence of this, geology has already made the discovery, that not only are many strata of the earth's crust full of organic remains, but that strata to an almost incredible extent are wholly composed of them—composed of them to such an extent, indeed, as to suggest the inquiry whether those rocks which exhibit no traces of pre-existing animals, and are therefore named azoic, are devoid of such traces, not because there were no living beings at the time of the original deposition of these strata, but because the central heat, the abyssal pressure, and the chemical action to which these rocks have subsequently been subjected, which have obviously changed them much (so much, indeed, as to have gained for them the name of metamorphic rocks), have obliterated all the traces of antecedent organisation.

No doubt the existing state of chemical hypothesis, as popularly held at present, implies that all the silicium, all the calcium, &c., which constitute the skeletons of these protista and protozoa, existed before the organisms in which these elements are found, nay, existed for ever, or, at least, from the commencement of creation, so that, instead of having been really secreted in any measure by these organisms they were merely taken up by them into their bodies from without. But if we do not embarrass ourselves with the chemical hypothesis alluded to (which rests on very insufficient evidence, and begins to be very seriously called in question, even by chemists),* if we fall back upon simpler views of the inner structure of material nature, and look to the obvious tendency of geological observation, we shall be led rather to infer that it is not with respect to ourselves merely, not among such animals and plants merely as happen to be visible to our eyes, that life precedes death, but that, far more extensively, possibly even universally, what is now dead is only what has been left behind of what formerly was alive. At anyrate, what we actually observe as to the relation of the organic and the inorganic, the living and the dead in nature, is this, that every living thing, either during its life excretes, or after its dissolution leaves behind it, a certain quantity of ashes or mineral matter. That all this, in every case, has been introduced into the living organism in the very forms in which it is given out by it, is generally maintained. But it is merely assumed, it never has been proved. Nor have many experiments, especially of late, been made to test it, because experiment in

* The popular chemical hypothesis alluded to is to the effect that there are in our planet some 64 elements, or different kinds of matter, the least particles of none of which are transformable into each other in any circumstances, or in any period of time, however long, and all of which are simple, primordial, ultimate, or even eternal, and eternally dissimilar to each other. The chemists may decline to express it in such strong terms, but it cannot be denied that on such a hypothesis all geological, all chemical investigations are conducted. It is incredible, however, that such a hypothesis can stand much longer, because it makes all nature in its ground a chaos, and the interpretations of the phenomena a continual struggle against everything that is feasible; its only evidence, meanwhile, being the fact that chemists have not yet succeeded in decomposing these 64, as they have gradually succeeded in doing with regard to other substances. But though these 64 were (like all other material particles) of a molecular nature, why should the chemist expect to be able to decompose them, since, before they have come into his hands at all, or been subjected by him to his mimicry of natural processes, they have been subjected for untold ages to the infinitely greater ordeal of the white heat of the sunbeam, the central heat and the volcano, and have survived it?

general is the slave of hypothesis, and experiments which in their issue might possibly damage a favourite belief, are generally avoided.

It may be stated, however, and it ought not to be forgotten, that, looking simply to nature for information, ashy or mineral matter may have what may be called a meteoric or fiery origin, as well as an origin from vital action. But here we have to consider the latter only.

Let it not be hastily inferred that, in that grand conception as to the origin of our solar system, which goes by the name of the nebular hypothesis, anything is implied which is inconsistent with a primeval vitality. Not but the attainment, on the part of our planet, of a certain central mass and density, implies the evolution in its interior of an intense heat altogether incompatible with the existence of such organisms as are known to us. Not but, in the present epoch of nature, it is only at a considerable distance from the centre that the temperature is mild enough for life, in such forms as we know it. But during the long ages of change from the nebulous state (whatever that may mean) to one which, in the central parts of the future planet, should be more dense, there is no evidence that heat was developed so rapidly as to be destructive of life, either about the centre or at any distances from it. On the contrary, the whole progress of scientific discovery rather points to an epoch of condensation, so long continued, so orderly and so gradual, that the degrees of heat generated may possibly have been the very temperatures which are most congenial to the construction of living beings, and to their enjoyment of life.

Viewing the world, on the other hand, as condensed to the degree that it now is, a sufficient cause appears both for those metamorphic and igneous rocks which geologists recognise, and for the obliteration of all traces of antecedent life during the genesis of these rocks. Notwithstanding this, however, every year is discovering organic remains further abroad, and deeper down among the strata, previously noted as azoic.

But since the reader may suspect that my argument might tempt me to exaggerate on this subject, let him peruse the following extracts from a small work* which very happily combines the character of scientific and popular, which, moreover, records only the work in building up the concrete part of our planet, of the simplest animals, and among these, the work of those only which give calcareous, not siliceous skeletons.

The author first adduces the work of the Foraminifera :—

" Our path now lies for a season in the crust of the earth. We must look into that mighty record of the past for proofs that the sarcode amœba (see figs. 1, 2, 3, 4, 5) was a creature ultimately designed by

* Popular Illustrations of the Lower Forms of Life, &c. By C. R. Bree, M.D., F.L.S., F.Z.S. London, 1868.

omnipotent power to build up the solid portion of the world which man was destined to people. It has been the province of very recent investigators to prove that the amœba is the oldest of known fossils, that it was the architect, unconsciously working away at a period so remote, that we can only realise it in any intelligible form by comparing it with the space we are told to think of, supposing the nebulous matter, which is resolved into stars by the high power of Rosse's telescope, reveals to us suns which are the centres of systems like our own."

"Now, beginning with the first fossiliferous period . . . . . we find the Laurentian rocks composed of quartz, slate, and limestone, forming in many parts a beautiful veined green marble, occupying in Canada and New York an area of 200 square miles, and having a known thickness of 30,000 feet, and an assumed one of 90,000 feet, or, as Sir William Logan has suggested, a thickness which 'may possibly far surpass that of all the succeeding rocks, from the base of the Paleozoic series to the present time, carrying us back to a period so remote, that the appearance of the so called primordial fauna may be considered a comparatively modern event.'

"This extraordinary formation has been recently proved to have been formed almost entirely by Foraminifera. . . . . . The amœba, which formed the shell of the *Eozoon canadense* in those ancient waters, was at least twelve times the size of any known living species of the present day.

"It is not known as yet if any other animal lived in those ancient seas. On this subject the stone book is silent. There is, however, no decided proof that other animals may not have existed coeval with the Eozoon, although their remains are not found in the Laurentian rocks. They may have been destroyed by the heat which metamorphosed the sediment of those seas into Labrador felspar, hypersthene, crystalline limestone, and beautiful green veined marble, but which left intact the cast of the Foraminifera, and so perfectly, that the fossilised pseudopodia may be seen, like tufts of silver wire, radiating through its canals and chambers.

"For the time being then, at least, the *Eozoon canadense* must be considered as the oldest example of organic structure which the records of geology have revealed to us; and we must receive as a fact of science, that the lowest known sedimentary strata, for the depth of from four to sixteen miles round the earth, have been formed by the lump of jelly called the amœba. The student will note that, although these Laurentian rocks have only been observed, say, in North America, Ireland, Sweden, &c., yet the geological inference is that they would be found to occupy the same position in all other parts of the world if the more recent formations were removed. Thus, were I to bore into the crust of the earth, at Colchester,* I should expect, at a distance of 13½ miles, to come down upon the Laurentian rocks.

"There is something truly practical and satisfactory in the revelations of a science which shows to us how gradually the crust of the earth was built up, and how far down that vista of time, in which the imagination may revel in awe and wonder, those mighty preparations were begun which culminated in the creation of man himself.

"It is, however, in the Cretaceous group of strata that the Foraminifera begin to appear most abundantly. It may surprise many of my readers when I tell them that the chalk cliffs throughout the world consist mainly of the remains of the Foraminifera. We cannot go where we will and examine the stupendous Laurentian rocks, but we can visit our chalk cliffs at Dover, or wander over our Sussex downs; and we can also realise the great use to man of chalk, when we see our farmers spreading it upon their stiff clays; and we can, without much trouble, follow the "white hills" into Ireland and Spain, France and Greece, for an extent of 1140 miles. We can follow them from the south of Sweden to Bordeaux, for 840 miles; and we can measure these cliffs, and find them to have a thickness of from 600 to 1000 feet; and then we can sit down in some snug corner and smoke our pipes, and ponder upon the wonderful fact that all the most important parts of our earth's crust have been built up by an animal, sometimes so small as only to be seen through the microscope—a creature without muscle, bone, nerve, or blood-vessel, a mere lump of jelly!

"At the beginning of the Eocene period, and contemporaneously with the London clay and Paris basin formation, we first observe the appearance of the Nummulite. It reached its highest point of development about the middle of the Eocene period, when at least fifty species are known to have existed. It then began suddenly to decline, appeared in less and less numbers in the later Tertiaries, and in our seas only a single species is known to exist.

"But in the period above indicated, this little Foraminifer had formed beds of enormous thickness and great extent in the crust of the earth. Some idea of these extraordinary strata—known as the Nummulitic limestone—may be gathered from the following extract taken from Professor Haughton's 'Manual of Geology,' pp. 176 and 177:—'The geological distribution of Nummulites is most remarkable, as they are found along the entire line of mountain chains from the Pyrenees to Thibet, and occur at all altitudes from 8000 feet and 10,000 feet in the Pyrenees and Alps, to 15,000 feet in the Himalaya mountains; they

* The author resides there, and his statements were originally addressed to people there.

form a geological zone stretching W.N.W. to E.S.E. from 10° W. long. to 55° E. long., having a width of 1800 miles. Farther to the east it narrows considerably, but the entire length from west to east embraces 98° long., and its breadth from north to south ranges from the 16th to the 55th degree of north latitude.

"The Nummulitic limestone surrounds the entire border of the Mediterranean Sea and the Black Sea. It constitutes a large portion of Egypt and of Asia Minor. . . . . . It is found in the elevated regions of the sources of the Tigris and Euphrates, and extends from Upper Armenia to the Persian Gulf. It also stretches eastward from Armenia along the valley of the Araxes by the chain of Elburz and the plateau of Irau, as far as the mountains of Cabul and the Punjaub. It completely surrounds the valley of Cashmere, and rises in the chain of the Himalayas to a height of 15,996 feet, from which altitude it descends on the south-east of the chain along the right bank of the Indus, forming the lower hills of Beloochistan. Still farther to the east it is found in the mountains of Kossya, between the Brahmapootra and the plains of Bengal.'

"I need say but little more to prove the important agency assigned to the amœba in building up the crust of the earth. In all this there is a vast proof of the design with which this lowly organism was created. Take away the Laurentian rocks, and the chalk, and the Nummulitic limestone, and *the crust of the earth would tumble to pieces.* And yet they were formed by a lump of jelly that could only have the blind instinct of self-support and self-preservation.

"And the same design is being carried out in our time for the probable creation of a future world, in which man himself may be the most important fossil.

"The bed of the Atlantic Ocean, even at a depth of two miles, is covered by ooze teeming with Foraminifera, ninety-seven per cent. of the soundings at the above depth being found by Captain Dayman to consist of Globigerina. They are principally found in the Gulf Stream and follow its course. Does this indicate a future group of hills or mountains having such a range? The coasts of Australia are crowded with living Foraminifera; in fact, they are found in the soundings of most tropical seas, and the greater the depth, as a rule, the larger the specimens. They occupy fifty per cent. of the ooze in the deeper waters of the Mediterranean, Adriatic, Red Sea, Canaries, West India Islands, east and west coasts of South America, St Helena, and Isle of France.

"The history of the Foraminifera is part of that of the earth. I have in this paper endeavoured to show how intimately the study of animal life is connected with those higher generalisations upon which the science of geology is founded. How much is our interest heightened in that drop of water under the microscope, and that protean lump of unsymmetrical sarcode called amœba, when we associate them with the physical architecture of the world, and the forethought and design of that world's Creator!"

The author afterwards proceeds to notice the work of the coral polype (fig. 6).

"But there is no part of the interest attached to the coral of greater significance than that which we shall find connected with its history in the formation of the crust of the earth. The thousands of islands, which, for the space of 16,000,000 of square miles, are found in the Great Pacific Ocean, are almost entirely formed of coral. All the north-east coast of New South Wales, for upwards of 1000 miles, has a barrier reef of coral. In the Indian Ocean the immense chain of islands known as Cosmoledo, Saya de Malha, Chagos, the Maldivas, and the Laccadives, are all formed of coral occupying a space of nearly 2000 miles. The eastern coast of Africa, from Mozambique nearly to Ajan, upwards of 1000 miles, is an immense fringing reef of coral. The coasts of the Red Sea are almost entirely coral. Turning again to the Indian Ocean, we find the south-west coast of Sumatra and the southern coast of Java fringed with coral. From the northern extremity of the Celebes to the Philippine Islands, thence to Bashee, Patchow, and Loo Chow, and back to the China Sea, we find the Paracells and other large islands all formed of coral; and, lastly, for I need not continue details, the islands of Bermuda and the West Indies are surrounded by fringing reefs of coral.

"This rapid glance at the works carried on *in the present day* by the polyp which forms the coral, will give some slight idea of the immense importance which this creature has possessed in fashioning the form of the earth's surface. If we go below this, and look at the records of its working in time, our astonishment will be vastly increased. Some of the most interesting problems connected with the age of the world are solved by these records."

The creatures by which such mundane quantities of concrete earthly matter are produced, are, as I have stated, of the simplest structure, and usually the individual is of a very minute size, or, more correctly, their organism is, so far as appears, but little differentiated, and they are so minute, that probably there are many of them which are too small for even the highest power of the microscope to render visible. At any rate, beneath the horizon, within which the highest power of the most powerful microscope can detect objects or particles different from the liquid medium in which search is made, there is every reason to believe that there is still a lower, or, shall I not rather say, a higher world teeming with life. I have said that these creatures of the dawn, or protozoa, are to be described as not visibly differentiated, that is, they do not exhibit to the eye many different tissues or organs as larger animals do. For this reason they are commonly spoken of as very simple—mere specks of living jelly—and so forth. But all that is really seen is this, that they consist of a transparent substance, which, when burned, gives universally the same chemical elements as its constituents. But when it is considered how manifold and how marvellous the powers of that substance are, reason checks the eye in affirming this to be so very simple. As to their external forms, they are so multifarious as seemingly to defy any generic descriptions, even the most reserved. Sometimes even the same species, nay, the same individual, appears to have power of affecting all imaginable forms, and to be a very proteus, which name has indeed been appropriated for some of them. To acquaint himself with them, the reader must have recourse to works on zoology, and mark the forms and powers of the Rhizopoda and the Infusoria, the Hydrozoa, and the Actinozoa, as also the succeeding orders."

Referring to the sponges also, the author from whom I have quoted so largely makes the following remark :—"The sponges are found fossil in the oldest rocks. They attain their maximum in the chalk. Most of our flints have a sponge or its spiculæ as a nucleus, round which the siliceous matter has accumulated." The sponges are, indeed, very different from the other creatures which have been noticed. But they do not fail to contribute their share to the crust of the earth.

There are other organisms also which, without any adequate reason, naturalists are more disposed to refer to the vegetable than to the animal kingdom, or to an organic realm lying between the two which has been named that of the *Protista*, by which it appears that material for rocks has been supplied to a vast extent. Such are, for instance, the Diatomaceæ, of which thousands of species have been ascertained to be still living and dying, and leaving their beautiful siliceous shells behind them to increase the quantity of dead matter in the crust of the earth. Composed entirely of such shells, extensive strata and beds of stone are found here and there among the strata of our planet. They are individually so minute, that Ehrenberg estimates that, in Bohemian Tripoli, there are 187 millions in a single grain weight, and yet, at that place there is a stratum extending over a wide area which is no less than fourteen feet thick.

To the seremarks some others may be added from Lyell's Elements of Geology.

He states what is still more interesting in reference to the view in which we are now regarding such occurrences in the upper part of this stratum, that there is "another heavier and more compact stone, a kind of semi-opal, in which innumerable parts of Diatomaceæ and spiculæ of the spongilla are filled with, and cemented together by, siliceous matter. It is supposed that the siliceous remains of the most delicate Diatomaceæ have been dissolved by water, and have thus given rise to this opal, in which the more durable fossils are preserved like insects in amber. This opinion is confirmed by the fact, that the organic bodies decrease in number and sharpness of outline in proportion as the opaline cement increases in quantity." Treating of the origin of metamorphic rocks, the same author makes these remarks:—"Now, the alterations above described, as superinduced in rocks by volcanic dikes and granitic veins, prove incontestably, that powers exist in nature capable of transforming fossiliferous into crystalline strata—powers capable of generating in them a new mineral character, similar to, nay, often absolutely identical with that of gneiss, mica-schist, and other stratified members of the hypogene series. The precise nature of those altering causes, which may provisionally be termed plutonic, is, in a great degree, obscure and doubtful; but their reality is no less clear, and we must suppose the influence of the heat to be in some way connected with the transmutation, if, for reasons before explained, we concede the igneous origin of granite." And again,—"The total absence of any trace of fossils has inclined many geologists to attribute the origin of the crystalline strata to a period antecedent to the existence of organic beings. Admitting, they say, the obliteration, in some cases, of fossils by plutonic action, we might still expect that traces of them would oftener occur in certain ancient systems of slate, in which, as in Cumberland, some conglomerates occur. But, in urging this argument, it seems to have been forgotten that there are stratified formations of enormous thickness, and of various ages, and some of them very modern, all formed after the earth had become the abode of living creatures, which are, nevertheless, in certain districts, entirely destitute of all vestiges of organic bodies. In some the traces of fossils may have been effaced by water and acids at many successive periods; and it is clear that, the older the stratum, the greater is the chance of its being non-fossiliferous, even if it has escaped all metamorphic action."

In the review of what has been advanced in this chapter, it may, perhaps, strike the reader as strange, that the burden of the earth's crust should have been laid to such an extent upon animal beings, and not rather upon plants. The prevalent impression is that the vegetable preceded the animal kingdom. And it is certain that vegetable remains, in virtue of the carbon which they contain, can give solid strata which may possibly last as long in the crust of the earth as any other, attaining, in different epochs, the successive states of flaming coal, glance coal, and ultimately plumbago. But minute research into the intimate structure of the living cell in plants has shown that its lining and living part is the same as that in animals, and that the vegetable matter or cellulose which characterises plants is of the nature of a very delicate shell encrusting and protecting, and supporting the living part. The simplest plants, therefore, must be viewed as farther away from the beginnings of life than the purely sarcode animal, and analogous to those which, for their protection and support, secrete calcium or silicium. But here the philosophically minded observer is reminded how inadequate merely popular distinctions are to form the ground of a truly scientific classification of the productions of nature. Multitudes of organisms present themselves in the field of the microscope with regard to which some of the most approved naturalists maintain that they cannot be called either animals or plants, and for which they have, therefore, instituted the kingdom *Protista*, as lying between decided *Protozoa* and *Protophyta.* Meantime, no generally accepted definition either of an animal or of a plant exists. A popular conception merely, which is extremely vague, is left to rule. This classification of organic nature, therefore, into three kingdoms instead of the two, the third embracing organisms in which it is thought that the characteristics neither of animal nor of vegetable organism and life distinctly appears, implies no more than this, that in descending the scale of organisation, now in the line of animals, now in that of plants, with a popular conception of what an animal and what a plant is, we come, at least, in both lines to organisms, with respect to which we do not know whether to refer them to the one kingdom or to the other, and so, as a haven for our ignorance, we institute for them a third kingdom. Nothing, however, either in organisation or function, has appeared in them to justify such an institution. Its true place, therefore, if such there be at all, is that of a parenthesis or appendix for receiving organisms which, at present, it is deemed improper to classify in either of the two established kingdoms of nature.

As to the eight classes of Hæckel's Protista, most of them have hitherto been regarded as animal organisms, and have been treated of by zoologists, and there is no good reason for making them change their zooic place. This also is eminently the place of his first order, his Gymnomera, of which *Bathybius Hæckelii* is adduced as an oceanic, and *Protamœba primitiva* as a fresh water, example.

Moreover, these Monera, it is to be remembered, are the organisms out of which Hæckel raises the whole of the living world, both of animals and plants. There is nothing, then, in his class Protista that is adverse to the views now advanced, which regard animal nature as the first manifestation of life in our planet.

CHAPTER III.

INDICATIONS OF A CERTAIN RECURRENT FORM (THE NAKED OR APPENDICULATED SPHERE) AND CERTAIN NUMBERS (12 + 20 = 32) IN LIVING BEINGS AND THEIR PARTS.

BIOLOGY, the science of life, when treated as a branch of philosophy, which is our present aim, has for its object to know and understand, as also to account for, the forms, the structures, and the functions of living beings and things.

Now, in order to make any progress in such an inquiry, our intellectual weakness obliges us to direct our attention first to those which appear to be most simple, and which, therefore, are probably most easily known and understood. Moreover, according to our conception of the origin of nature, this is also to begin at the beginning; so that here philosophical propriety sanctions what logical necessity imposes.

It will assist us if we consider these simple beings as they exist—

1. In confinement.
2. In freedom.

In the former situation are those living and ever transforming cells of which the entire animal organism, so far as it is alive, consists, and of which, when these living embers are normally being transformed and cemented together, it is in the main constructed. But comparative anatomy is still in a state far too crude and rudimentary to undertake the discussion of these organic elements. Nor, indeed, does it seem desirable to consider them as individualised beings (Endocystica), distinct from those which they constitute.

The case is different when there are found in animals, organisms which are truly animated, and which yet form no organic part of the animals themselves in which they are met with, such as entozoa, gemmæ, ova, spores, &c., of which we may adduce, as an example, fig. 1, *a*. It represents (highly magnified) an encysted or reposing Gregarina, an inhabitant of the intestinal canal of insects, &c. It also represents *Amœba sphærococcus* in repose, also highly magnified. This animal consists of a spherical mass of plasma, which encloses a nucleus together with a nucleolus, and is surrounded by a cell membrane."—*(Hœckel Schöpfungsgeschichte* p. 380.) But it may equally well represent the drawings of ova in the same work, both those of invertebrata and vertebrata (see Plates VI. and X.), and in physiological works generally. Respecting amœba in this reposing form, Huxley says, "No doubt many persons will be struck with the close resemblance of the structure of this body to that which is possessed by an ovum. . . . . You might take the more solid particle to be the representative of the germinal spot, and the vesicle to be that of the germinal vesicle, while the semifluid sarcodal contents might be regarded as the yolk, and the outer membrane as the vitelline membrane. I do not wish to strain the analogy too far, but it is at any rate interesting to observe this close morphological resemblance between one of the lowest of animals and that form in which all the higher animals commence their existence."*

That the lowest and the highest products of organisation, and those whose development is the most diverse in the world, should thus appear to the eye to be so similar, shows the utter hopelessness of morphology if the natural eyesight alone is to be consulted, without due regard also to mechanical or rational principles. Naturalists too often think of the last molecular or moving things rendered visible by the microscope (which, compared with ourselves and the common furniture of the world around us, are of course very small), as if they were among the very least things of a molecular or moving kind that nature produces, when, in point of fact, they more probably are to the latter as African elephants to infusory animalcules. Physiologists, also, too often allow themselves to infer homogeneity in a soft mass or morsel of any kind, however marvellous its powers may be, merely on the strength of having observed an equal amount of transparency, or a similar coloration all through! But surely such an inference is most unwarrantable, even on the principles of the most obvious logic. And moreover, the spectroscope has shown of late, and that to the eye itself, how incompetent this organ is, when informed by natural light merely, to observe differences, even when they are of quite an elemental character.

Can anything be more certain than that the intimate structure of a human ovum, which has latent in it the power of developing into the form and structure of a human being, and that only by an action sustained during many years, must be entirely diverse from that of an amœba, which within a few minutes can extemporise legs and arms for itself, nay, a stomach also, and digest its food without a visible trace of any of those viscera which man must possess, and that in a state of

* An Introduction to the Classification of Animals, p. 8.

health and activity, before he can do the same? And how diverse, also, must the intimate structure of that amœba be from a morsel of glue, with which, nevertheless, biologists compare it, and which, no doubt, gives a somewhat similar image on the retina? Let us indulge in no such inferences, in no such comparisons. They are most unscientific. Our eyesight was given us for showing us neither the limits of the universe nor far into it, but, on the contrary, for enabling us to seize our food, and take notice of such objects as are dangerous to our bodies, while these objects are yet at some distance from us, and we may possibly master them or escape from them. For all that belongs to the sphere of science, properly so called, it is the mind's eye reviewing the observations of the material eye, it is the interpreting power, it is reason alone, that we can consult with advantage.

However, in the field of observation and thought to which these remarks apply, this much appears to the eyesight, that individualised objects, when their simplicity is a maximum, and when, though possessing life and capable of development, they are in a state of repose or hybernation, tend to possess a spherical or cellular form, containing within it a nucleus, as also often a nucleolus. This, the form and structure of every cell when it is as yet unchanged, and is just beginning its individualised or centralised life, and every encysted Gregarina, Amœba, &c., and spores and ova in general, demonstrate.

But let us not proceed farther without asking whether we are right in regarding Endocystica, Gregarinida, ova, and the like, as complete, unmutilated, or unshorn objects. They are all intestinal, internal, or imprisoned organisms, occupying walled interiors where delicate extensions of their substance, as well as free locomotion, must be forbidden them. Hence, is there not reason to suspect that they may be defective, or shorn of those delicate extensions of substance or organs of locomotion which are the characteristic endowments of animal nature? Suppose, then, that we have similar morsels of protoplasm, let us say, in a situation where free growth and movement are possible,—in open water, for instance,—what do we find respecting simple organisms when there? To this the general answer is, that while, previous to change, as in imprisoned organisms, the spherical or spheroidal form and an analogous structure still prevail, yet the free organism is now usually furnished all over, or in certain parts, with banks of oars named *cilia*, by the rapid movement of which it can change its place, and flit about freely in the liquid medium in which it exists. Such are the first forms of algæ, sponges, polypes, medusæ, &c. (figs. 8 and 9).

But here among such objects there is to be observed a very remarkable difference. Some of them (fig. 9) change their spherical form but slightly if at all. They do not develope into other forms, either plant-like or peculiar. On the contrary, they produce, either in their own interior, or in juxtaposition to themselves, small bodies like themselves, which, by their own opening or dissolving away from around them, they liberate, and which, when liberated, have the power of continuing the race.

Moreover, many of these spherical or spheroidal bodies (see fig. 9) show themselves to be not homogeneous or simple spheres or spheroids, covered more or less with *cilia* all over, but composite forms, built up of a multitude of little spheres or spheroids, each spheroid having perhaps only four, more usually only two, and ultimately only one cilium (figs. 10 and 11). And here one is tempted to consider the exquisite structures and phenomena displayed by lasso-cells, spermatozoa, antherozoa, pollen, &c. But the connection of the flagellate form in the individual with the spherical group, out of which it has emerged, has not been studied, and a statement of the relations here would be almost purely theoretical, and incapable of verification. It may be remarked, however, that when the cilia or linear appendages are long, their normal nisus at the spherical keeps twisting these appendages round the spheroid to which they are attached, and so imparts to them usually a spiral or undulating motion. Of this, endless illustrations are given in the reproductive elements (see the aquatic cryptogamia, such as the Characeæ, &c).

Very manifold are the representatives of cilia (tentacula, pedicellariæ, ambulacral tubes, &c.) Cilia are, indeed, so slow to disappear entirely, that they are still found, and that retaining their vibratory action, on the surface of many membranes in the most highly-organised animals (in man himself, indeed), when one face of the cells constituting that membrane is free.

But let us now hasten to remark that many ciliated spherules, instead of opening up and liberating offspring like themselves (as Volvox, fig. 9), after they have indulged for some time in moving freely about, thus diffusing the species while the parents die, settle down on some suitable solid stage; and by-and-by there grows from them spiculated or tentaculated structures in endless varieties in nature. Of these nascent structures, the polype form, a hydra-tuba (fig. 12), may be taken as an illustration. This in its turn may ultimately give being to a free swimming medusa (fig. 13); and of these there is in nature a host so multitudinous, that in certain latitudes and states of the weather they render the very ocean luminous, and supply food even for the whale. Or emulating a plant, the polype may bud and branch again and again into all the exquisite forms of the zoophytic and coralline world. Still, it appears that all this branching and building again is but a nisus by means of axis budding upon axis, and equator branching upon equator, to retain the growing forms overhead or in its limits with the ambient medium, as spherical as the conditions of existence will allow. In consequence of the space below it being occupied by the rock or other object it rests upon indeed, the zoophyte scarcely even attains to more than the hemispherical in form. And further, in proportion as the animated mass becomes less completely individualised, it inevitably becomes at the same time less centralised and less emulous of the spherical. The more of dead matter also which the composite structure contains, whether siliceous spiculæ or calcareous granules, the less symmetrical its form may be expected to be, the greater the departure from a spherical contour.

We take then the appendiculated sphere as the type of form for a fully individualised organism when most simple, perfect, and free, as for instance the ciliated ovum, fig. 8, which may represent either the ovum of a cristatella, or one of those bodies found in flint, which have been called Xanthidia (fig. 15). As other examples, I may also allude to the Radiolaria generally. Say *Heliosphœra inermis* where the protoplasmic arms and body are supported by a siliceous skeleton of a spherical form, composed of hexagonal lace or lattice work, possessing the most geometrical and beautiful structure. It is, indeed, so elaborate and so geometrically accurate, that it is difficult to draw a diagram of it. Let us, therefore, be content as a type of this whole class of beings with fig. 14, the sun animalcule, a familiar microscopic object.

And here there meets us one of the most interesting and important facts in the economy of animal nature, namely, *the secretion* by the living organism of matter which is dead, and *its utilisation* to give support to the living organism. If animals are ever to attain to any considerable size or durability, something of this kind is manifestly needed; for the living parts of an animal, inasmuch as they must be always easily transformable, must always be mobile, and therefore always soft and yielding. But if they are so, then except when the animals are very small, and live in a medium which is of the same specific gravity as themselves, they must be liable, under the sustained action of gravitation and incident forces, to be all flattened and spoiled as to form. Hence a necessity that supporting material be provided. Now this, animals in general have been enabled to do for themselves. Certain of the particles of their bodies die, and become dead, most probably, after they have served the purposes of life and been exhausted. And these dead particles become good material for constructing supports; for a dead particle is merely a particle which is not readily liable to change, a particle, therefore, just such as is wanted as material for the skeleton of an animal. Now, of such a kind are pre-eminently particles of silica, and of carbonate and phosphate of lime, that is, the very substances which the simplest animals secrete in great quantities. And hence, in early ages, abundant material for forming the shells and skeletons of animals. But is this all that we have to say upon the subject? Does this economy come to a close here? In the lapse of the time during which our planet gives evidence of its existence, a time which seems all but infinite, must not the accumulation of such dead stable matter in it be immense? And why, therefore, when we come to consider the case of the planet itself, should we part with the conception, that this dead matter is provided as material for a support? Why not a support a shell or crust, not merely for the individual organisms which secrete it, but for their general home, the planet itself, which would have been too soft and yielding without it?

Not that we are to infer that the entire mineral matter of the earth, or even the greater part of it, has, or must have been formed, in this way. Dead or mineral matter would also form rapidly, all independently of the secretions or excretions of organised beings, as soon as the nuclear condensation of our planet had become so great, that the central heat thus generated surpassed a certain temperature. After that, the heat would transform the aqueous matter of the primæval abyss into mineral matter. Much of the crust of the earth may, therefore, have had what may be called a meteoric as well as an organic origin. But in keeping with the view advocated in this work, it cannot be denied, that the whole tendency of geological research is to increase the quantity of organic matter. This is, according to our view, the normal mode of the genesis of the crust of the earth; and by this view the same theory of the origin and use of mineral matter applies equally to the microscopic amœba, and to the world itself.

As to the origin of this dead matter as a secretion or excretion of that which has life, it is probably necessitated by the law of the conservation of force, and inevitable, the elements of the material system being what they are. But though inevitable, it need not therefore be useless. It is universally admitted, that it is needed, and even necessary to be a support to living creatures, almost from the least to the greatest; and now it is suggested that it is also necessary to the world itself, in order that the world may be a suitable theatre for their existence and entertainment. Here then we have an instance of that marvellous economy, which is constantly presenting itself to the reflective student of nature. Some object or incident appears which, other things being as they are, is unavoidable, which, therefore, may be expected to be merely an encumbrance, or if it serve one purpose, that is all that can be reasonably looked for; instead of which, however, it is found to be essential to the whole system. And we are taught that it is only in consequence of want of compass in our own thoughts that we ever felt a difficulty about it, and were tempted to wonder rather than to adore.

Such a generalisation (which refers to the same category, and uses the same ideas to explain the existence of every shell of a microscopic Orbulina, and that of the crust of the earth itself), will not go without a criticism invoking the aid of ridicule perhaps. But that can be easily borne. That is not the worst of it. The reader will not fail to perceive, that such a view is entirely at variance with the chemical hypotheses which are at present in vogue. But it is no less true, that it is not at variance with the traditions of science and philosophy in general, from the earliest times. And if it explains phenomena, it is worthy of being listened to; for the actual state of science has no account at all to give of the origin of the materials of which the supports of animals are formed—unless, indeed, if it be that they were to be found as ingredients in the original cosmic vapour—where, however, it is certainly as uncomfortable for reason to find them as in the bodies of animals, or in the crust of the earth.

At present it is generally believed, as has been stated, that these minute animals take up the mineral matters found in them entirely from the waters of the ocean or of the ambient medium, be what it may, in which they live. And, doubtless, if these materials occur in the animal's food, the animal will utilise them for the construction of its skeleton. And probably the quantity which any individual animal, even the longest lived, can transform of one element into another—of nitrogen into silicon, for instance, is infinitesimally small. But to maintain that all the dead or mineral matter found in animals has been brought into them from without for ever, is to maintain a hypothesis which puts a stop to all biological research, and which, by the experimental results of some of the best analytical chemists, is believed to be contradicted even by the incubation of every hen's egg. And if it be so; if during no more than twenty-one days, phosphorus and calcium, even in appreciable quantities, make their appearance in so small a mass as the chick in ova, how great must not the whole quantity be which has been produced by life since the first creation, a period too remote to be distinctly conceivable? It is, indeed, affirmed by many chemists that, after making the most careful experiments on incubation, they do not find, either by the balance or otherwise, any evidence of the increase of quantity of lime or phosphoric acid, or of anything else which may not have come from without, during the change of the glairy contents of an egg into a feathered fowl. But how many millions upon millions of atoms must have been produced before any of our gross senses could in any way detect them! Compared with the fineness of molecular nature, the most sensitive chemical balance with $\frac{1}{100}$ of a grain in the pan, is a beam in a warehouse weighted with bale goods.

But to turn from the dead to the living, it may be said that the simplest forms of life have been best observed in amœba. In its reposing form, or what may be called its form of hybernation or when encysted, *A. protoccus* is represented in fig. 1, *a*. The tribe is one which contains immense multitudes. In a state of activity, *A. radiosa* is represented in fig. 1, *b*. Here the nucleated " morsel of glue" has extended in all directions legs and arms, which it can extemporise out of any part of its body when it is hungry. These it gathers up when it has caught a particle of food, so as to form, in like manner of itself and for itself, an extempore stomach which can digest whatever is taken into it. Again, therefore, after this phase of activity, the amœba resumes in a general way the spherical form.

And here, were we to take anything like a full review of the forms of the most simple and abundant creatures, we should require to give much time and many words to the medusidæ, those specks of jelly (see fig. 13) with which the ocean teems to such an extent that in certain states of the weather, as has been already stated, the sea is even rendered luminous by them. But we must content ourselves here with stating that, on a general view of their forms, it may be said that when they have other means of locomotion (such as cilia, &c.), they are more or less *spherical* (Beroe, &c.) When they have no other means of locomotion but their own forms they are more or less *hemispherical* (Medusidæ). Now, while the spherical is of all forms the worst shaped for effecting locomotion by itself, the hemispherical, which is but half spherical, is well calculated to do so, especially if the edge, or equatorial part of the form, be thin and mobile; for then it must be ever tending to make a nisus at the spherical; and this tendency cannot but be sustained rythmically, like all other similar vital movements. In a word, the mobile-equatorial edge must be ever pressing downwards and inwards rhythmically, bent on forming another pole opposite to that which exists already. And thus its hemispherical form must propel the animal in the direction of the already existing pole. For the same reason (the development of the spherical) we are also to expect, as appendages to the hemispherical fan or umbrella, marginal tentacles, &c.; and in the line of the axis an axial polypite, stomatodendra, &c. In short, our theory accounts to a great degree of minuteness for the unseemly and strange organisation of the medusidæ, which, considered as to form and structure merely, seem to have rare pre-eminence in nature, since they are not only so abundant but often attain to a size so large that nothing else in nature that is so simple and so aqueous can approach them.

The bioplasmic protozoon, while it forms a support for itself more or less of a rigid or stable nature, and in so doing is obliged to die in part, is not always, or even often, able to maintain its unity, its individuality. Most usually it becomes in this case a composite animal, or a community of animals. This is beautifully illustrated in the amœba tribe itself, or the Rhizopoda as they are called. The animal secretes or excretes abundantly calcareous matter for protection and support. But, except in a few instances, it cannot detach itself from its own house before the time when a child or germ is at the door bent on building another house like that of its parent and adhering to it. And hence multiple cabins and inhabitants in one vessel, with doors, or rather port-holes, all over and through it. Hence, in a word, the most extensive tribe of the foramenifera, which are still forming and in the former ages have formed, as has been shewn, to a very considerable extent, the crust of the earth. Still, in this tribe unity and individuality reign to such an extent that, in modern times at least, the community is never a large object, and its structure is always symmetrical. Nay, here also it looks as if the architecture of the whole community were so conducted that the finished work should be as spherical as the conditions of growth would allow. Thus some, as Globigerina, Orbulina (fig. 3), are spherical, and those which depart farthest from the sphere may be described as either axial, as Nodosaria (fig. 4), or as equatorial, as Spirilina (fig. 5), the others being intermediate, as if constructed upon the skeleton of the sphere as the type—that is, upon an axis either as such or as a system of meridians with an equator. In these cases, then, the animal is no longer single; it is a composite animal. Still, however, the principle of individuality reigns to this extent that the form of the composite animal attains a stage in which it is full grown, and its further growth comes to a close in a limited specific form.

But when the bioplasmic creature has been differentiated to such a degree as to be a polype, with tentacula definitely limited in number (coral polype, fig. 6), the secreted dead matter has gained upon the living to such an extent, that the creature can no longer, in the most notable cases, call a halt to the continuous deposition of that matter. The deposition, therefore, goes on continuously until the limiting or destructive action of external nature prevents further additions. Such are coral-forming creatures, Sertularidæ, &c.

In reference to these, it is only such as grow upon projecting points, or in other favourable situations, which remind the observer of the sphere, and that overhead only.

With regard to each individual polype, however, it displays the sphere in its gonospore, and its own form when retracted or reposing.

When expanded, also, it displays an equator formed by a system of expanded rays or tentacula when the creature places itself fully in relation with its environments, the body and axis of the animal being the hemisphere on its own side, and a circling eddy of water, caused by the tentacula on the hemisphere, on the aqueous side.

But when the animal retreats, so as to be as complete in itself as it can, the equatorial radii, or tentacula, close up as meridians, thus developing the spherical. And ultimately all is huddled together in a little ball.

Ascending the animal scale, it is to be found that unity has regained its ascendency again in the sea-urchins, star-fish, &c. And in these the spherical or its skeletal elements, the cylindrical or axial (sea cucumbers, &c.), and the equator or radiated disk (star-fish, &c.), appear more distinctly.

I shall not, however, at this stage of our work, proceed to trace the prevalence and recurrence of the spherical in form any further. Let us rather hasten here to remark, that while a type of types, or archtype of form, thus appears to be embodied in organic nature, something of the same kind may be observed as to the number of parts and organs displayed by organic beings. There are prevailing and recurring numbers, their sub-multiples and multiples.

Thus, in polypes when developing, how often do the tentacula commence in four and rise to eight, a number which continues permanent in all the many and infinitely numerous coral polypes. Among the finest algæ, also (Ceramiaceæ), their most conspicuous feature is the tetraspore. And in the peristomes of the mosses the series of numbers is found complete. It is, indeed, true that this dichotomous series is precisely that which the law of the equilibration of equal and similar forces gives also. But that consideration explains only a few of the phenomena, and is no argument against the existence of typical numbers at the root of nature. It merely bespeaks the universal harmony of things; and it gives no reason why in the dichotomous series certain numbers rather than others should prevail. Thus, in the very extensive family of mosses very widely distributed in our planet, and containing many hundred species, the number of teeth in the peristome is, in a vast majority, thirty-two. And what if that which we may call the peristomes of the most perfect animals give the same number! No anatomist can give a reason why the teeth of a mammal should be so many as they are, and neither more nor fewer. And yet how strangely they manifest certain numbers. Thus, in the human species the first set of teeth are twenty in number. To these, in the permanent set, twelve are added, making thirty-two in all. The same is also the number in the apes of the old world, which most nearly resemble man. It is also the number in those flocks and herds which man makes his companions and grazes in his fields and parks, and which are so invaluable to him. Other animals, again, as the pig, have first thirty-two, and when all their teeth are mature and accounted for, they have $32 + 12 = 44$. Others, again, such as the new world monkeys, when looked at with their jaws closed, may be regarded as having their teeth in three sets of twelve each, 36 in all, one set of twelve being the incisors, guarded on both sides by the canines; while in the large and important class of carnivora, there are twelve incisors.

Other parts of animals, also, are remarkable for the constancy of these numbers where the development is complete. The same numbers as the above—that is, $12 + 20 = 32$, may be seen to recur in the limbs of the most perfect kinds. At their peripheral terminations they give $4 \times 5 = 20$ fingers and toes. The same numbers are also sometimes beautifully seen in the structures by which the limbs are attached to the axial part of the skeleton when these structures are fully developed, as in some lizards.* And these twenty are connected with the trunk in all the four by three parts (forearm, arm, and hand; thigh, foreleg, and foot), that is twelve parts, making $20 + 12 = 32$ in all. Nay, it might be shown that to all appearance the bones of the limbs (of recent species at least), when each limb is taken by itself, have thirty-two and twelve as their limits in point of number. Thus, in certain reptiles in which the bones of the extremities are very perfectly developed, it is seen that the tarsal bones still consist of two rows of five each, corresponding to the five digits beyond them,† giving—arm or thigh bone, 1; forearm or leg, 2; carpus or tarsus, 10; metacarpus or metatarsus, 5; phalanges $(4 \times 3) + 2 = 14$ —in all, 32. In hooved quadrupeds and birds' wings, on the other hand, these bones are reduced to about 12 in number.

Very interesting it would be to make a study of the subject with a view to see to what extent these numbers shew themselves in the axis of the animals when that axis is constituted by serial repetition, as first in the annulosa and ultimately in the vertebrata. But here the polymorphism, both of the axial elements themselves and of their appendages, according to the use which they serve, makes the investigation difficult and the results uncertain. Thus, insects, which abound to such an extent all the world over, have $\frac{12}{2} = 6$ limbs. Very numerous species of crustacea (lobsters, crabs, &c.) have $\frac{20}{2} = 10$, and so are named decapoda; while the various tribes of arachnida (spiders, mites, &c.) have $\frac{32}{4} = 8$. All vertebrates above the lowest have $\frac{32}{8} = 4$, which in the highest almost part company, as two (legs) and two (arms).

Moreover, it has been ascertained that the number of axial elements or somites in the higher arachnida and crustacea are precisely twenty in number; while in the insects the number never exceeds twenty, as it

* See Huxley's Manual of Anatomy of Vertebrated Animals, p. 36. 1871.

† See Professor Owen on the Nature of Limbs, p. 27.

may in the myriapoda. Adding to these twenty, six legs and four wings, and allowing two for generative organs, we obtain thirty-two numerical elements in these exquisite creatures, whose numbers in genera, species, and individuals, are so vast and varied all the world over.

This train of thought might be extended to a great length, and applied to the vegetable as well as the animal kingdom. But naturalists at the present moment are quite indisposed to listen to a doctrine of types, properly so called, or anything that insinuates such a doctrine. If they admit of types at all, their types are merely individuals selected empyrically, which appear to possess eminently the features displayed by a large number of individuals. And as to chemists, though they are just as much in favour of types as naturalists are opposed to them, yet their types are merely the quotients of percentages drawn and quartered most cruelly and without any sanction from nature, and so arranged as to be a sort of mockery of an algebraic series, with new constants in every term developed according to the powers of H.

$$ClH \,.\, OH_2 \,.\, NH_3 \,.\, CH_4 \,!$$

Molecular science, under such a conception of the system of nature, may be compared to that of Botany in 1583, when Cæsalpinus proposed to distribute all herbs according to the number of seeds they bore up to four. Such Procrustian treatment will never do. The dance of nature is not one, two, three, (on the floor of the dead world), and a hop (to carbon in the living world). Molecular nature is as varied and beautiful as crystalline and organic nature. This is indicated by every most minute object which the microscope renders visible.

What will be thought by those who come after us of the science of the present day ! Within the entire sphere of the visible, in mineralogy, in botany, in zoology, in every individualised object which nature produces, symmetry is seen to be a dominant fact, and is duly attended to by the student. But as soon as the objects become so small as to be invisible to our eyes, though they be the very elements of which the visible objects are built up, symmetry is quite forgotten and no regard is paid to it by the chemist ! On the contrary, he ever aims at cutting down his molecular formulæ if he can till the controlling substance remains as one atom only, in which case it never can enter into a symmetrical structure except when it is in the centre. Happily, of late he has often become wiser than he intends to be, and, by mistaking two atoms for one, has constructed many formulæ in harmony with the law of symmetry, and which represent whole molecules, and not half molecules as used to be.

CHAPTER IV.

THE THEORY OF DEVELOPMENT—ITS DEFECTS—THE CONDITIONS OF ITS COMPLETENESS.

Though it be but a little of nature that we have seen in the preceding pages, yet we have seen enough to prepare us for the embarrassment in which many thinking men find themselves when not content with the knowledge of the mere anatomy of an object, as the eye and the fingers can give it, they feel the necessity, in order to intellectual satisfaction, of knowing something as to its antecedents, its cause or origin.

Often, indeed, a beautiful and beneficent design appears in the object, bringing immediate intellectual relief and satisfaction along with it, giving as it does the assurance of the existence of mind at the time of the origination of that object,—mind possessing all those attributes which our own intellectual and moral nature leads us to ascribe to the Author of all.

But this is by no means always the case. Sometimes the object is such that it is difficult to discover design in it at all, or, at any rate, such design as could have originated in a beneficent mind. After much thought, perhaps, its structure or function seems still a stumbling-block in the way of every theodicy.

Of these two aspects of nature, the former presents itself in the morphological discoveries which have been reached in the last chapter. If living matter, when individualised as plant or animal, tends, when not exerting itself, to be contained under a spherical contour, we see here the realisation of a beautiful design—a design that does not rest its evidence upon sentiment, however sufficient for a basis sentiment may be in general, but upon pure mathematics. Thus, living matter is a delicate and tender kind of matter, and of all kinds of matter it is the most precious. Delicate and tender it must unavoidably be, because to be living is to be mobile and easily transformable, yet without being fluid. And plainly it is, of all kinds of matter, the most precious, because to it alone sensibility attaches and enjoyment is possible. It is manifestly important, therefore, that living matter, when partitioned and distributed into small individualised morsels which cannot but be subject to easy destruction by the incident forces to which they must be unavoidably exposed, should be shaped in such a way as would least expose them to laceration or solution, and would retain for them, at the same time, the condition most favourable for the exertion or deployment of that inner force which is implied in the idea of life.

Now, it may be mathematically demonstrated, that both these conditions are most completely fulfilled when the living morsels referred to are shaped into little spheres, meaning by spheres, spherical superficies —such as cells or skins, with their contents. Thus, supposing a sphere to be exposed to incident forces on all sides or in any direction, it is the best of forms to resist such forces: *first*, because being equal and perfect arch all over, it requires the greatest external violence to dent or to deform it; *secondly*, because having a minimum of surface or exposure in relation to its contents, it limits to the smallest number the incident forces which can bear upon it and possibly disturb it; *thirdly*, because all its living parts and particles being so connected together that they are all as near as possible, to one and the same point within it, namely the centre, it may be inferred that they are more fully than is otherwise possible, at the bidding and under the control of the vital force, which is itself in the individual a centralised unity, when the individual is bent in exerting that force. Thus the actual institution in nature of the spherical, as the form of an organism which needs protection in the midst of its environments, and which is also to be capable of dilatation and a full play of its life when its environments are not dangerous to it, is manifestly a most wise and benignant design. It is not merely positively wise, which is generally all that can be affirmed of arrangements that are judged by moral feelings merely. But if the principles of mathematics be the same everywhere, and belong to the intellectual system of the universe, which we cannot doubt, it is superlatively wise. There is no presumption, therefore, in maintaining that it is worthy of adoption by a Perfect Being as a designer of forms for His most tender creatures and their constitutive particles.

Such a satisfactory result is not, however, always, nor indeed even often, easily obtained by the minute observations of nature. When, for instance, calling to mind even the little that has been stated already, we turn from the forms of organisms to the number of their parts, then by all the lights which the actual science of the day, either pure or applied, has to throw upon them, no design, no reason appears why these numbers should be what they actually are; why they should be, for instance, so often as they appear to be, 32, with its dichotomous submultiples 16, 8, 4, 2, and its components 20 + 12, with their dichotomous submultiples 10 and 5 and 6 and 3. There is nothing in these numbers, indeed, which speaks against beneficent design as possibly universal. But neither does beneficent design, nor indeed any design, at first sight at least, appear in them to explain their preference to other numbers, such as 7, 9, 11, 13, 15, 17, 18, 19, &c. They cannot be adduced as antitheistical indications, but they may be affirmed to be not inconsistent with atheism, if atheism be argued on other grounds.

There are other arrangements in nature of such a kind, however, that, in the first impression which they produce, they seem positively antitheistical; as, for instance, the seemingly useless multiplication of organs in the animals near the top of the scale involving great liability to lesion and disease. How can the dyspeptic, in whose stomach his dinner (which, however, he cannot do without) lies like a lump of lead, be prevented from secretly envying the digestion of the Amœba, which, without either stomach, or liver, or pancreas, or intestine at all, and merely with a skin which it can turn into a stomach when it is hungry and food comes in the way, digests that food to perfection? What can be the design, it may be asked (in so far as the science of the day is concerned), of such complications both of conservative and of reproductive organisation, as we find around us and possess ourselves, so often in all seeming to our misery?

Often, also, where design appears,—nay, is most exquisitely realised by the most ingenious application of mechanical principles,—how difficult to regard that design as of a beneficent nature! It is not every one who can see a ground of adoration in an exquisitely realised design, all irrespectively of the end for which that design exists. When the Professor of Geology in the University of Dublin shows so well (as he always does) the exquisite muscular and osseous apparatus provided for giving most effective action to the foreleg of the tiger, it is not easy to forget (as he seems to have the happiness to do) the uses so destructive of sentient life for which this mechanism exists.

Nor does this feeling of mystery in nature, when viewed as the work of a beneficent Creator, attach to the contemplation of such objects only as are visible to all. Reference has already been made to the entozoa. To these add the occurrence of parasites generally, and that in the noblest animals, as also the parasitic theory of zymotic diseases which is coming more and more into favour, and it need be no matter of wonder that this aspect of nature, when dwelt upon, should have led even in the popular mind to a great change of view, or at least to great dubiety, as to the origination of nature. Those whose part it would have been to maintain the traditional conception of the theology of childhood, namely, that every individual species of animal originated in a special volition and a direct forthputting of plastic power by the

Author of all, though such a view were tenable from the catechetical side,* do not now enter the discussion in such a way as to secure the attention of men of science; while the latter, as if in revenge upon this view and its inconsiderate assertions, as also in part, perhaps, in revenge for the anathemas which theologians hurl against them, seem to find a pleasure in writing with apparent atheism where, in point of fact, there is neither occasion nor room for anything of the kind.

This is remarkably the case with the theory of development, which is regarded as the triumph of modern times, not only as stated by men of science generally, but by Mr Darwin in particular, as the theory of natural selection, or the survival of the fittest? And here let us call to mind what this theory is, and that not as applicable to plants and animals only, that is, the whole sphere to which alone Mr Darwin applies it, but as it is presented to science by Hæckel, in his "Natural History of Creation," where it is carried up to the "cosmic gas" of the nebula, from which it is supposed that the solar system has resulted.

There is certainly a high intellectual charm when a single idea is proposed for rule, and is made to cover a field so extensive as to space and time. And it is not the subversion of this idea, it is rather its duplication, its completion and its regulation, which appear in these pages.

The theory of development, though seemingly very simple, yet does in reality involve many hypotheses, many complications, and many imperfections. Thus, first, it assumes that while organic species are deducible from each other, transformable into each other, still, from first to last, from the first Monera or germ of Monera, down to the last man, or the last individual of the species that shall come after him, it also assumes that they are all built up of a considerable number of different kinds of matter, such as oxygen, hydrogen, nitrogen, carbon, calcium, phosphorus, &c., there being sixty-four altogether of such material elements in our planet alone! And, accordingly, it admits that these elemental species, unlike the organic species which they constitute, are not deducible from one another; nor are they in any length of time, nor in all eternity, transformable into each other, but radically and inexorably dissimilar. Here, then, is a thorough vitiation of the theory of development as a complete theory. Here is a thorough breakdown in that theory, and that somewhere near its origin. How, then, it may be well asked, is such an incongruity tolerated? To this it is to be answered, that it obtrudes itself in consequence of this fact, and this

* It is strange that such a view should still be maintained by any who stand upon the Bible as the ultimate authority in such matters. In the sacred narrative of the creation, as recorded in Genesis (which certainly every scholar and thinking man, whatever his religious views, must respect), it is expressly said that the command was given to the earth, to the waters, to bring forth.

fact alone, that the chemist in his laboratory cannot succeed in decomposing these sixty-four substances. Hence it is inferred that they are essentially undecomposable, simple, and untransformable! And on this hypothesis the whole science of mineral geology proceeds. But when it is considered that all of these chemical atoms, before they have come into the chemist's hands at all, have been secularly consolidated and mineralised, so as to be able to withstand the ordeal of the volcano and the central heat, compared with which the most powerful analytic agencies of the laboratory are but a mimicry, is it for a moment to be supposed, although their internal structure were still molecular, that they would break down in the chemist's hands? Surely all his containing vessels, which are but things of human art, must go to pieces before them. Nay, surely his own eyes, which are very tender structures, must first be put out. According to views implied in our molecular morphology, the decomposition even of a small quantity of hydrogen, if it were possible, would be accompanied by a tremendous explosion.

Here, at any rate, is there not a great fault in the theory of development considered as a philosophical conception? One-half of it is contradicted by the other half. In so far as the visible forms of plants and animals are concerned, it derives the more complicated from such as are more simple, proposing ultimately to derive all from one kind of germ. But the particles which constitute that germ it regards as having been for ever the same as they are now—some out of sixty-four intransmutable atomic species, varying in atomic weight from 1 to 206 in this planet alone! It extends the doctrine of development and transmutation to species which happen to be visible to such eyes as we have, it denies it to such as happen to be invisible to us. Now surely, in the mere capacity of giving a picture on the human retina, there is nothing to indicate such a complete change in the economy of nature. If all animals and plants have been obtained by the secular synthesis of transformed Monera, and the differentiation of the organs composed of them, thus giving in the last analysis one form and kind of protoplasm as the root of all, the pursuit of the same line of thought, the same theory applied to the atoms of the chemist, with their various properties and atomic weights, gives, as the common ground of all, a single material element, each chemical atom being a structure composed of this material element, but so stable as to be indecomposable in the laboratory. Let this be granted, and the theory of evolution, whatever may be the case as to its cogency, at least possesses a scientific form. It is no longer, as it is now, a conception which breaks down midway between its first and its last terms. Meantime, however, let it not be inferred that what has now been stated is really against it when it is true to its own name, and is itself fully developed. As we proceed we find, by the most convincing evidence, that this unity and identity of the material element in the last analysis is actually the case.

But letting science in this respect stand for the present as it is, and supposing all the sixty-four atoms of the laboratory, or rather, perhaps, some very high multiple of this number, to constitute that cosmic gas from which the solar system has been evolved, the theory of development shows itself to be as imperfect on the great scale and in point of extent as it has been shown to be in point of homogeneity in its intimate material. Beyond that cosmic gas there certainly is the æther, a medium, which no longer can be ignored in any physical theory of nature. What, then, is the relation of the cosmic gas to the æther? Of that, so far as I am aware, nothing is affirmed by evolutionists. It is obvious, however, that to render the whole system of thought homogeneous, it would need to be shown that all the phenomena of material nature may be explained by supposing that just as all organisms are the synthetic developments of one kind of Monera, and all chemical atoms and molecules the synthetic development of one kind of material element, so is the material element a synthetic development of ætherial elements. And that it is so is shown in this work, so far as it has been found necessary to prove convincing to the author.

But having reached the æther, is the theory of development now fully extended and as all-embracing as it ought to be? Plainly not. Reason cannot rest in the conception of a congeries of particles which are wholly blind and devoid of feeling and thought, diffused throughout all space, believing such particles to be the first of things. Reason, if it is to enjoy intellectual repose, "a Sabbath for thought," which it tends to keep holy, can have it only in finding, beyond and above all things else, an unity, a power, intelligence, personality—in one word, God. This is the only legitimate haven of a theory of development.

And that from Him, as the Author of all, nature may be reached with those very features which it is seen to possess, it is the aim of the following pages to maintain. This is indeed a very old view, and a view very generally embraced till now. But though nothing has been observed in modern times that seems to conflict with it which was not also observed in ancient times, yet respected names in science not only decline to accept it, but argue against it. To me it seems essential to every philosophy which shall be in harmony with intelligence, that it shall be based upon an unity. Nor has a philosophy all the claims to intellectual regard which it possibly may have, unless that unity be an intelligent Being. To suppose thought and feeling to wake up for the first time in that which was previously blind and dead, mere matter and force, from all eternity, is to me nothing short of absurd.

CHAPTER V.

THE TRUE PROTOPLASM AND THE COSMICAL LAW.

That an Almighty Being, in whom all perfection dwells from all eternity, should call into existence a creation, which viewed in reference to Himself could not but be a finite and therefore an imperfect thing, has to some minds seemed incredible, and to all that exists as substantial reality they assign an existence from eternity. But looking to the question in a less abstract point of view, reason neither imposes nor sanctions such a conclusion.

In the nature of sensibility a sufficient reason appears why existence may have been awarded to a creation, however perfect in Himself the Almighty and Eternal One may be. Thus the well-being of sensibility is happiness; and happiness in comparison with all other things is so precious that to it all other things, in the last analysis, owe all the value which they possess. Whatever may be fixed upon as the chief good, if it be not happiness itself, must receive that title only in consideration of its being a producing cause or a safeguard of happiness. That which is both itself incapable of feeling or of awakening feeling in any other being is quite valueless. But happiness, on the other hand, nay, even the possibility of happiness, mere sensibility, is held to be of such inestimable value that no creature in the possession of its senses parts willingly with its life; and it is a favourite view in the present day with regard to all organised nature, to look to the individuals which compose it as all struggling for existence—a conception implying how precious life is universally felt to be.

Is it overbold to affirm, then, that happiness must stand very high in the regard of a Being who is supremely intelligent, wise, and good? Nay, is not the maintenance or the increase of happiness in a secure manner precisely what is meant by goodness? Must not the Supreme Being, thus, inasmuch as he is supremely good, surely tend to maintain and to increase happiness?

As to Himself, his omnipotence implies that He is from all eternity supremely happy or ever-blessed; for if He were not, from what we know of the nature and laws of sensibility we know that He would immediately put forth his omnipotence to bring his sensibility into a state of well-being, that is, into a state of happiness.

The Almighty, then, is ever-blessed. But He is also perfectly good. Now, how can his goodness find a field for its manifestation so long as He alone exists? Such is the nature of sensibility that it implies individuality. So long as one only exists only one can be happy. What, then, in these circumstances are we to expect? In answer to this, it at once appears, that by awarding existence to sentient creatures, placing them at the same time in conditions suitable to their well-being, happiness may be increased proportionally to their number, and therefore to all but an infinite extent. Here, then, granting the existence of an Almighty Being who is perfectly good from eternity, do we not see a sufficient occasion for his awarding existence to a creation?

It is, indeed, true that this argument applies to a creation only in so far as it consists of sentient creatures, while with regard to the actual creation it will be said that such creatures form but a very small part of it. Every new day, however, as has been already stated, the progress of scientific discovery shows that the amount of life in our planet both has been from most remote periods, and is now immensely greater than was but lately supposed. When the amount of strata, both in extent and depth, which the microscope shows to consist more or less or entirely of the remains of organisms which once lived on the surface of our planet or in the depths of a primæval ocean, and the geological doctrine of metamorphism are taken into account, it is hard to say, even on the ordinary evidence of induction, as has been shown, what portions of the crust of the earth may not have been originally concreted by living beings. And if the molecular views of this work be accepted, it follows that perhaps all that is individualised and yet non-sentient is of the nature of a falling away, an excretion, or a rejectamentum from an universe of living beings and things.

Let us open, then, with this idea of a creation—(a supposition, it must be admitted, not without good reasons to support it)—*a creation such as to teem with life up to the limits which the conditions of individualised existence in different regions of space will allow.*

And now, what—let us ask—must the material of such a creation be? To this it surely will not be denied that the proper answer is PROTOPLASM! This is the substance which above all others excites the wonder and admiration of the scientific biologist of the present day, and on which he is disposed to devolve all biological phenomena. Let us, then, ere we proceed farther, pay our homage to protoplasm. But at the same time let us view our protoplasm, not in its chemical but in its formal and functional characteristics. As to the chemical composition of protoplasm commonly so-called, it consists of a variety of those particles which still defy the analytical processes of the chemist, and which he is disposed to regard as elements, but which, as we have seen, when viewed as primordial and untransformable, do not fall in with the theory of development at all. The protoplasm of the biologist is also a substance which is more or less opaque or visible. The protoplasm which we now conceive as the material of the whole creation in its first state, when development is to begin, must, on the contrary, be altogether homogeneous, and doubtless perfectly hyaline or invisible also. But none the less must it be well entitled to the name of protoplasm, nay, it alone must be justly entitled to that name; for it is the first of created things, and being the product of an Almighty Being it must be altogether plastic in his hands. It can have no constitution of its own derived from itself. Both externally and internally it must be what Timæus calls, *αμορφον δέ καθ' αὐτὰν καί ἀσχημάτιστον, δεχομέναν δε πασαν μορφάν,* and what Moses calls תהו ובהו. And to these conceptions I shall add nothing by way of description; for there is no use in attempting to conceive it as if it alone existed. For however negative in itself of all properties except being or substance, yet the almighty and ever-living Creator is at all times and everywhere imminent to it, and bears upon it, as the material provided by Himself for the manifestation of his wisdom, his power, and his goodness. It must, therefore, possess specific properties though not aboriginally its own. It must, so far as the finite can with respect to the infinite, unless prevented by Him, reflect, represent, embody, and body forth his attributes and Being.

This the Creator may of course, in the exercise of his omnipotence, prevent, limit, or regulate altogether according to his will, so that in successive epochs in all space, or possibly during the same epoch in different regions of space, there may be in all but infinite variety of creations or worlds differing from each other more or less in their structure and economy. But, in the absence of such limiting volitions, must not the created substance embody or body forth the Creator's attributes and being so far as it is competent for the finite and the created to do so? This must be admitted and remembered. Still, however, as will appear more fully hereafter—but I may state now—there is a limitation to this. Certain properties and demands with regard to that which exists with limited extension in space are inexorable. Even Omnipotence cannot alter them. Beautifully, therefore, does the Doric tract ascribed to Timæus Locrus say, "There are two causes of all things—*mind*, namely, the cause of those which are produced according to intelligence; and *necessity*, the cause of those which are produced by force according to the dynamics of bodies. Of these, the former is essentially good, is named God, and is the principle of all that is best. In the latter necessity reigns."

Still, with such limitations the primal substance of creation must surely be fully obedient or assimilated to the Creator, and that not in a transient manner, but abidingly or permanently. In its nature the primal substance, the true protoplasm, must be an assimilative substance.

Here, then, let us take that step which, though it may not have in this place the sanction of an unquestionable deduction, yet comes out so fully afterwards that I have no doubt about it, and feel it to be important to state it here. It is to the effect that, supposing this our protoplasm to be partitioned into individualities, then each and all of these individualised beings and things would, up to the full measure of their capacity, not only tend to assimilate themselves to the ever-present Being to whom they owe their own being, but they would tend also to assimilate themselves each to itself with respect both to space and time; as also, they would all tend to assimilate one another. Now, this is our cosmical mode of action or law; and on the strength of this law alone, without invoking the aid of any other, we pretend to explain all those phenomena to which the physicist, the chemist, and the biologist usually address themselves.

And, here, that this may not seem to the reader merely as an idle boast, and that he may have some idea thus early of the way in which this law applies itself to phenomena, let us in passing adduce some illustrations of its action.

Permanent Properties.—And, first, we may remark that it must impart these, to that which, considered by itself, is destitute of all properties except that of substantial existence. In fact, whatever its first form or its form the first moment of its creation, an object if fully individualised as one and simple must, under the law of assimilation, assimilate itself to itself in the next and in every successive moment, and so on, until its own self-assimilative action is modified by some other action from without. Here, then, we see as a first product of our cosmical law of assimilation, the perpetuation of an original mode of existence and the establishment of permanence of properties, provided the individual object considered be such that it is not subjected to change from within itself by the reciprocally assimilative action upon one another of its own parts or principles.

Permanence of Species.—Here we see also the ground of the well-known fact in nature, namely, the remarkable persistency and permanence of well-constituted species.

Species in Genera.—But it follows also, in virtue of the reciprocal activity of the law of assimilation, that species must be associated as genera. Everything, in a word, that acts from out of itself must tend to inscribe or mirror itself into everything else, and, therefore, there must be throughout all creation a general harmony and homology.

Such are the first products of the law of assimilation, and let it not be supposed that it is to the material world alone that this cosmical law applies. Let us here adduce some illustrations of its action from the mental or spiritual world.

Perception is the assimilation of the mind as percipient to the object presenting itself, so far as the inner action and situation of the mind permits.

Remembrance is the assimilation of the mind in its present state as a percipient to some former state in which it existed as such.

Reasoning is the mind remembering with exclusion of all ideas save those which are assimilated, and therefore similar to one another, and show themselves to be so.

Imagining is the mind remembering; either with selection of such ideas as are assimilated to the object which the mind has in view; or more at random and in that spontaneous play of analysis and synthesis, which actuates the mind as an individualised being in the former case, as a member in a system in the latter case.

Judging is the mind in the exercise of this synthetic or analytic power, reviewing the assimilation, and affirming the similarity complete, or more or less or not at all, of two or possibly more ideas or objects presented to it.

Idea, as the term implies, is an assimilate not physical or material, but such as is proper to mind of some real object, material or mental.

And so on with all our other modes of mental activity, which, when viewed generally, are regarded as our mental faculties. They are all, in so far as they are articulate, and possess a definite mode, truly operations of the cosmical law of assimilation. If it be said that in these examples there is already another law introduced besides the cosmical law of assimilation, namely, that which gives a play of analysis and synthesis, the answer is that this play is not due to another law co-ordinate with the law of assimilation. It is a product of this law operating in a higher sphere, analysis being the human mind in the exercise of its free activity, assimilating itself to the Divine mind in respect of his all-penetrating power or omniscience, and synthesis the same in respect of his all-embracing power or love.

To this, the Divine bearing of the cosmical law upon the human mind, man owes reason also; and as the return movement of the mind upwards, religion. The only human faculty that is not an illustration of the law, in the same sense as all the others, is our mental liberty or power of choice. And even this is due to the law, though in another sense, for it is the assimilation of the human mind to the Divine mind in respect of the power and perfect freedom of the latter. Liberty, therefore, is the very ground laid for the image of God in the soul of man.

But to proceed; in the world of physics, as illustrations of this same law of assimilation, it may be said that—

Attraction is the assimilative action of two or more atoms or masses as to the space they occupy. Nor is it the well-known phenomenon in general only that our cosmical law gives. It gives also the mode or law of the phenomenon when pure and simple, namely, attraction according to the inverse square of the distance. Thus the attraction of any centre, viewed as an energy attaching to that centre equally all around and reaching to an unknown distance (which is the usual conception), must, according to the law of assimilation, be distributed in spherical superficies around the attractive centre, all of which superficies must be in energy assimilated to each other, whatever their radius or distance from the centre. Now, these spherical isodynamic superficies or shells increase in size as the square of the distance from the centre increases. The attractive energy in any points or equal areas in any of them, therefore, must be in the same ratio inversely. Moreover, this deduction explains also the law of all radiant action. Nay, does it not explain that phenomenon of radiant action which seems so strange and which it is yet so necessary to assume in order to be able to explain the polarisation of light and heat, namely, that the excursions of the ætherial atoms are at right angles or transverse to the course of the ray? On the surface of the radiant object they must, according to the view here advanced, vibrate transversely, for they are chained to that surface, and are not free to proceed in the direction of the ray. Commencing transversely, the law of assimilation secures the uniformity of the action throughout. Moreover, independently of the form of the vibration at its origin, this transverse, rectilinear, elliptical, or circular vibration, is necessary in order to construct, as far as possible, the successive spherical superficies or shells which, according to our view, are the type of radiant action.

Inertia is the assimilative action of an atom (or mass compound of such atoms) this moment, in respect of motion or rest, to the state in which it was in these respects the moment before. Nor could any language be more in keeping with that proper to the law of assimilation than that in which the property of inertia is usually described. "If an atom or body be at rest it will continue at rest, and if it be in motion it will continue to move in the same straight line, with the same velocity, until it be disturbed by some force applied from without." An element of motion being the progress in space to the next point adjacent, it cannot but be an element of a straight line, therefore, under the law of assimilation the whole motion must be rectilinear. But the first element must also be accomplished in a certain element of time, and under the law of assimilation all equal elements succeeding must be accomplished in equal times. Plainly, therefore, the whole motion must be both rectilinear and uniform. And thus our philosophy presents to us, as a result of a purely scientific analysis and simply as a phenomenon, nay, simply as one of a class of phenomena which material nature everywhere displays, the inertia of matter; to explain which, it has hitherto been usual to invoke the aid of some unknown necessity, or the doctrine of a sufficient reason, or the rotation of the atom, or some hypothesis applying specially to inertia, thus placing it among singularities in nature (of which there are none) nay, sometimes placing it in contradiction with the attraction of matter, while here we see how distinct both properties are, though in perfect harmony as might be expected in the products of one and the same law.

Elasticity is the assimilative action of a form which has been disturbed to the form it had previously to the disturbance, and may be regarded as the inertia of form. It is commonly regarded as a phenomenon of a momentary or transient nature. But this only because of the limits of study imposed on the student in modern times, physics being separated from chemistry, and chemistry from biology. If the student in modern times were allowed to take comprehensive views of nature, as the old Indian and Greek philosophers did, it would have been seen long ago that there is such a thing as secular elasticity, as well as momentary elasticity; and various hypotheses, some of them unworthy of their authors (Pangenesis, for instance), might have been spared.

Heredity, Reversion.—These most notable phenomena are manifestations of the law of assimilation also, being as it were the working of a secular elasticity, developing or redintegrating in a succession of individuals the antecedent forms and structures which gave them birth. It is remarkable that, while to this phenomenon all biology owes its form, and is admitted to do so, yet it is never supposed that the same mode of action extends farther; and the consequence is that, during chemical experiments, seeming anomalies in affinity are being constantly met with. These so-called anomalies owe their existence to the tendency of the atom in the laboratory to redintegrate the state in which it had previously existed in nature, and from which the chemist has forced it to depart. Hence the reason, for instance, why atoms of silicium when set free from the mass resume two, atoms of aluminium three atoms of oxygen, or something else that will substitute it. The reason why the two minerals, as they occur in nature, are not similar oxides, depends on the different modes of their genesis, given in our Third Part.

Symmetry, culminating in Sphericity or Symmetrical Cellularity.—This is merely the assimilation to the utmost which circumstances admit in the situations of all the parts or particles which compose an individualised form to some one plane or line, and ultimately to some one point within that form. And here it will at once be affirmed by the reader that the universality of this tendency in material structures is by no means so obvious as in the case of attraction, inertia, and elasticity. And neither it is. The construction of particles, which are at once attractive and the subjects of attraction, into spherical forms, except when the centre of the form is also the centre of attraction, is very difficult. Hence it is to the heavenly bodies, in the first place (whose centres of attraction are also their centres of form), that we must look for the fulfilment of the law of assimilation in this respect. Now, with regard to all the millions of millions that there are of them, it is known that they are all spheres to the full extent that their rotation on their axis will permit. After these, we are obviously to look for the spherical in such acknowledged objects as are very small or light, so that the attraction of the earth or their weight has but little influence upon them; as also in those which have attained to their actual forms in a medium as nearly as possible of the same planetary attractiveness or specific gravity as themselves; in a word, we must look to the individualised objects which present themselves in the field of the microscope. Now, has it not been shown in chapter III. that there spherical forms are most abundant; and, more especially, that every creature when it assumes a state of repose is in that case most spherical; and this as to ova, spores, seeds, buds, &c., &c. And in a word, is it not agreed that the entire constitutive elements, equally of plants and animals before they are modified by aggregation, are spheres or cells? Yes, the number of objects in material nature, the largest, the smallest, which actually attain to the spherical in form, is inconceivably great, far greater than at first sight seems.

That every individualised object, crystal, plant, animal, tends to assume some form of symmetry, is so obvious, that it need not be insisted upon.

And here we may remark, in passing, an instance of what we see so often in creation, and which it is always so gratifying to intelligence to observe, I mean the discovery that a more comprehensive, possibly an all-embracing law, which in itself bears no signature of design, yet is such that when applied, it realises manifold benignant designs. Thus we have reached the sphere as a form for individualised objects simply as the form of culmination under the law of assimilation. It is that form in which all the parts or particles are most fully assimilated in relation to one and the same point within the form, and to one another. Here nothing in particular appears in its favour; but when we view it in reference to sentient or astral nature, we see, as has been already stated, that it is that form which, considered as a protection for itself or tender contents, is the strongest, being arch all round everywhere. It is also that which exposes the smallest extent of surface to stormy or unfriendly incident forces. Also that which, as a vessel destined to be filled with precious contents (as a brain-case, for instance), has the largest capacity in relation to the space it occupies, and so on. Not without good reason was the sphere looked upon by the ancient geometers as the most perfect of forms, and the regular polyhedra held in favour as steps towards the construction of the sphere; for the sphere may be regarded as that regular polyhedron of which the number of sides is infinite.

Within these limits, the tetrahedron on the one hand and the sphere on the other, it has fallen me to show, that all the completed molecules of nature tend to lie, and would lie but for the peculiar conditions of their genesis and history, and the incident forces which distract them.

Chemical and Electrical Action.—The well-known condition as to substances, in order that a chemical or electrical action may take place between them, is that they be in some respects dissimilar to each other. And what is this condition but that which implies a field for the operation of the law of assimilation? Moreover, it may be shown that in every case, that action has some kind or degree of assimilation as its aim! A hot and a cold body, when presented to each other for mutual action in respect of communicable heat (or the heat of temperature), or two bodies possessing inertia in respect of the motion of translation, or two elastic bodies in respect of their formal vibration, begin immediately to assimilate each other. In like manner, two specifically dissimilar molecules when presented to each other tend to unite and to remain in union, and by so doing are well known to merge their differences in the genesis of a new molecular species, from which the dissimilar properties of the components have disappeared. Also two bodies dissimilar as to electrical state (one positive, as is said, the other negative), when placed in the proper relation soon assimilate each other, merging their electrical differences in the production of a neutral electric state.

It is indeed in electric, and especially in voltaic action, that the influence and the persistence of this law is most remarkably displayed. Thus let two solids, which are in some respects dissimilar to each other in substance, surface, temperature, &c. (resin and fur, smooth glass and roughened glass, zinc and copper, antimony and tellurium), be brought into continuity, and made to bite each other by friction, pressure, difference of temperature, or otherwise, and forthwith a current of force generated in each and representation of it, passes upon the other, and an assimilation of both, more or less successful, commences. Moreover, by providing means by which these dissimilar but assimilative currents of force may circulate, so that each may back itself by a *vis a tergo*, and so strengthen and sustain itself, their existence may be demonstrated even to such eyes as ours (which were, however, given to us for entirely different purposes than the making of such discoveries ocularly). Thus there has been observed that mode of action on which such names have been bestowed as frictional electricity, the electricity of contact, thermo-electricity, though but little insight has as yet been obtained as to their nature.

But it is when there is a primary difference *as to state* between the bodies placed in relation with each other that the resulting phenomena are most interesting. Those which are truly homologous are far more comprehensive than the term "electrical" covers. Thus let a solid be immersed in any fluid such that action may take place between them, a volatile substance in the æther, a salt in a solvent, a metal in a menstruum, &c., then, as they are different as to state, an assimilative action as to state forthwith commences between them. The fluid assimilates the solid to its own state, the concrete particles separating from one another, and becoming distributed like those of the fluid particles. The solution of the solid by the liquid goes on up to a certain degree, when an equilibrium of assimilative force establishes itself between the two. After this, on a fall of temperature or other cause favourable to solidification, the assimilative action is reversed. The remainder of the solid, or a morsel of some other solid introduced into the solution, becomes a nucleus for action assimilative to it, that is, concretion.

Moreover, the concrete or solid may from the first possess the greatest assimilative power, as for instance, the soil, and by-and-by, the leaf, with respect to certain fluid particles diffused in the earth and in the air. From this there results the vegetable kingdom.

But, for the sake of familiar illustration, let us take the original voltaic cell, say, a zinc and a platinum plate united above by a conducting metallic arch, and beneath by a conducting liquid, such as dilute sulphuric acid, in which the united plates may be immersed.

And for the sake of distinctness of conception, and in order to be able to follow the details of the ensuing action, let us suppose that the dilute sulphuric acid employed consists of six atoms of water to each atom of oil of vitriol (monohydrated sulphuric acid), the proportion in which these two elements exist in white vitriol (sulphate of zinc).

Then, on immersing the two dissimilar solids or concretes in the liquid, the assimilative action commences, and since the apparatus is constructed so as to admit of that action taking the form of a closed current, when once begun it may continue; and the reciprocal action is of this nature. (1) The solids or concretes tend to solidify or to concrete the liquid. Meanwhile, (2) the liquid tends to liquefy or dissolve the solids or concretes. And ultimately (3) the persistent or insoluble solids (the platinum and cell walls) tend to solidify or concrete all. And when they have done their utmost in this way, the assimilative action is then consummated and ceases.

How one solid, as for instance copper or platinum, comes to be less assimilable to a liquid, such as our menstruum, than another, such as zinc, cannot be here stated. Such differences depend on differences in the form and structure of molecules not generally known, and in the case of platinum not known at all. But it is enough for our present purpose to know that one of the concretes in our couple is assimilable or soluble by our dilute acid, while the other is not. And now as to details.

First, on immersion in the menstruum of the dissimilar solids, which, being united by a conducting arch of the same nature as themselves, may be regarded, in the first instance, as one solid consisting of dissimilar particles, such as exists molecularly in a rod or plate of commercial zinc, let us ask, What are we immediately under the law of assimilation to expect? To this it is to be answered, that the liquid part of the apparatus being the most mobile, or the most easily changed, what we are to expect is this, the induction of a tendency to concretion, and consequently a state of tension, in so much of the liquid part of the apparatus adjacent to the concrete part as the assimilative influence of the latter can effect. Hence, if it be possible, there will be a complete concretion of the liquid or of its materials dissociated, in the two strata contiguous to the one or the two concretes. Now, though we do not possess such insight into the molecular structure in detail of dilute sulphuric acid as to be able to picture to ourselves the change induced, when from a natural state it is brought in this way into a state of tension, yet this is known that at the one concrete (the zinc) there tends to form a stratum of oxygen, and that at the other concrete there tends to form a stratum of hydrogen; oxygen and hydrogen being what may be called the non-liquid elements of water, or the terms in which moisture assimilates itself to concretes according to the equation—

$$Aq = HO,$$

which is by no means the statement of an identity as is commonly supposed.* Here, then, the first phase of assimilative action, which is successful, is on the part of the concretes, the zinc and platinum.

But meantime the liquid is not idle. It is insisting on the assimilation to itself of the solids immersed in it also. In a word, the liquid assimilates to itself, and dissolves into itself the zinc oxide as fast as it forms on the zinc surface. And thus the solidifying action of the zinc surface is not exhausted in securing the fall of one momentary shower of oxygen atoms upon it. The first course of oxidised atoms is immediately

* See A Sketch of a Philosophy, Part III. Chap. IV.

dissolved away or assimilated to the liquid, and the concrete surface is as fit as ever for receiving a second, then a third, and so on by the continuous decomposition of the water. Meanwhile (confining our attention at present to the oxygen alone) the specific impact of each atom of oxygen must, when embodied in the zinc, proceed according to the first law of motion, ever onwards so far as it can; and thus having reached the conducting arch above it, must traverse it, and turn round in it, and down the non-soluble concrete, and push through the liquid, which must admit of its doing so, thus completing the circuit, and thus backing and assisting in their incidence on the zinc, those particles of oxygen which are now tending to fall upon it.

In all this there is nothing, I presume, but what was long ago thought and justly received. The peculiarity which the introducing of the law of assimilation imparts to the old view is this, that this current of force instituted by the oxygen is not merely force in general, of which all that is to be considered is its quantity and direction, but force of which the form of its elements or their formative power is also to be considered, that form or formative power being representative or productive of oxygen. It will, perhaps, be said that such a conception is occult and mysterious. But is it more so than anything else which is adduced as a cause of particular phenomena? Is it more occult and mysterious than what is implied and confessed to be hid under the term electricity, or in the phenomena of heredity, to explain which one of the most gifted men of science of modern times has proposed the hypothesis of pangenesis? Our law of assimilation explains all these phenomena, and without any special hypothesis. And surely it cannot be against it that we meet with it everywhere in nature. On the contrary, something of this kind is precisely what is wanted in order to render natural knowledge as a whole accessible to the student, namely, something to put him in possession from the first of a master-thought which if he carry it along with him will present all nature as a harmony, and explain all that stands in need of explanation. But to return. There tends, then, in the single voltaic trough, in virtue of the assimilative action of the zinc to be a current of force representative of oxygen pulsating from the zinc surface up through the arch, down the non-resolvable conducting solid, and through the resolvable conducting liquid on to the zinc again.

But such an oxygen-formed current must, in virtue of the relation of hydrogen to oxygen, tend to place a corresponding number of atoms of hydrogen in an attitude to meet it. In a word, it must tend to penetrate the liquid which lies between the two metallic plates with threads of non-liquid aqueous matter, threads of which each element is HO instead of Aq. And thus proportional to the intensity and quantity of the projection of atoms of oxygen upon the zinc will be those of hydrogen upon the copper or platinum, or upon any other concrete diaphragm which may be interposed between the original couple.

Here, then, as matters now stand, we see that the phenomenon consists in a further fulfilment of the law of assimilation. At the surface of one of the plates (zinc) the liquid is assimilating or dissolving one of the concretes. At the surface of the other, the insoluble concrete (platinum) is assimilating or concreting the liquid so far as it can be concreted, it is attaching, detaining, encrusting itself with, hydrogen. (By-and-by, as we shall see, the concretes do more than this, and concrete all the liquid into the crystals of white vitriol.)

Thus the law of assimilation has in no small measure fulfilled its function. But it is the only law of molecular and of physical action generally. Now, therefore, since *the liquid* has filled its stomach with concrete particles, having assimilated the zinc in separate particles in union with its own, and *the solid* has taken out of the liquid a dry surface of hydrogen, having assimilated the liquid to the non-liquefiable, the voltaic action may be expected to abate, and the reciprocal currents to cease and fall into a state of repose. And indeed it is easy to see how this issue must take place mechanically. The coating of hydrogen on the platinum or copper must act like a non-conducting diaphragm or simple break in the circuit. The saturation of the acid also with zinc oxide has deprived the sulphate of zinc liquid of the power of dissolving more zinc oxide. For these reasons it is easily seen that the current must cease; and with these reasons science is usually content. And, being thus both mechanically and chemically sufficient, it will be thought by some that the explanation is sufficient, and that there is no need, nay, no place, for our law. But a complete scientific conception consists of two parts: first, the design or law; and secondly, the mechanism provided to execute or realise the design or law wherever it exists. The habit of looking only to mechanism is the plague and sorrow of the science of our times, which is issuing so sadly in the divorce of science from philosophy.

But we have now to consider, with regard to galvanic apparatus, that it is not molecular repose, it is the continuance of the current, and that as strong and steadily as possible, which the experimenter wants. Hence what he has to do, under our law, is to discover suitable means for clearing the surface of the non-soluble plate of its adhering hydrogen, and for replenishing the liquid with new solvent power or fresh acid. But say that he has succeeded in both these objects somehow, as by brushing and adding fresh acid, has he succeeded in thwarting nature and in keeping up his current? No; the two dissimilar metals standing face to face, though prevented by having to stand at a fixed distance, and by their state of solidified aggregation from merging their differences by mutual fusion into an alloy, yet act through the liquid, and by means of it they act assimilatively upon each other. In fine, the more mobile zinc surface assimilates to itself the more fixed copper or platinum surface. The latter comes to be coated with zinc. The original dissimilarity in the metallic presentations is thus overcome. The current ceases. With the fulfilment of the law of assimilation molecular repose ensues!

There is great scientific beauty, then, in Daniell's cell. By one stroke it clears the hydrogen from the non-soluble metal, and permanently preserves the original dissimilarity of that metal to the soluble metal, while, at the same time, it adds free acid to the liquid to supply the place of that which is neutralised by being assimilated with the zinc-oxide already.

But if means are not taken to prevent it, while the action is continued, not only are the metallic surfaces assimilated to each other, but in relation to them both as concretes, as also no doubt to the sides and bottom of the cell also ultimately, the whole liquid also is assimilated or concreted when it has cooled, so that it becomes wholly solid, constituting white vitriol or sulphate of zinc, of which nearly half the weight consists of water in some concrete state.

So much for electricity as an illustration of the law of assimilation. The phenomena of chemical affinity illustrate that law no less. In this sphere, and simply in virtue of that law, two dissimilar molecules when they meet tend to assimilate each other, and as the readiest way, rush together, merging their differences in the genesis of a new molecular species, in which the nuclei of the constituent elements may indeed be permanently dissimilar, but their temperatures and their ætherial atmospheres become confluent and assimilated.

Hence, all separable atoms and molecules viewed overhead are either prolate, axial, or positive in form, or else oblate, equatorial, or negative; and these tend to unite, whenever they have opportunity, working their way by successive unions as far as possible towards the construction of molecules, which shall be as nearly as possible spherical and homogeneous, that is, assimilated as far as possible in all their parts and particles.

And now, to bring these illustrations of the law of assimilation to a close, let me simply refer to that from which the name is borrowed—that process, namely, by which a living creature grows to its full stature, and its strength is replenished under the exhausting vital action from hour to hour. This process in highly differentiated animals undergoes corresponding differentiations and complication of conditions. In man, for instance, in order to effect it, salivary glands, stomach, liver, pancreas, &c., are required. An Amœba requires nothing of the kind, but needs only to wrap itself like a cloak about a particle of food, and forthwith that food is assimilated.

And here the question suggests itself, Why such complications as are met with in these animals which are by general consent placed at the top of the scale? Now, without proposing to answer such a large question here, these two remarks may be made—*first*, Complication seems to be necessary, in order to the segregation of nervous matter and the construction of a myo-neuro-cerebral system, which may be the mother and nurse of a soul or monad of a higher order than the merely material element, and an organism by which the cycle of the economy of material nature may be completed, and made to touch upon the spiritual world again and to contribute to it; *secondly*, Complication considered as differentiation is the condition by which the concrete state can be maintained when the conditions of existence are favourable to the liquefaction or the diffusion of the particles of the concrete. The law of union by dissimilarity, viewed either as a momentary or a sustained act (which is the basis of chemistry), holds good in physiology. In order that an embryo may continue as a concrete thing and grow while immersed and under the immediate assimilated influence of a liquid, as the embryos of all the higher animals are, it must be more and more differentiated. Otherwise it will be sure to be dissolved and vanish. To prevent this, indeed, as far as possible, the fluids in which it grows are already charged with those very substances which its solution would yield, thus reducing the assimilative action of the surrounding liquid to a minimum—all which statements are, however, now made too shortly to be acceptable or even intelligible, but which may yet be left in this state, being not for the present, when the popular demand is all for very light reading, when science is marvellously content with the attainments which it has already made, and when as to the method of science we are all told with more and more confidence every day, that all we can do for the discovery of realities is to go out of doors (leaving the inner man all alone) and to smell the present, comparing its odour with that of the past, and then turning our noses towards the future to follow them. Sensation, we are told, is the alone architect of all trustworthy knowledge, the author, both as to form and substance, of all that is belief-worthy—no such thing as intuition!—reason merely a habit rising from the long-continued use of the organism!

That such a method should be possible, and may seem logical, follows from that universal harmony and homology which our cosmical law imparts to nature. From this it follows that every great fact, such as sensation, may be seen to be reflected, and may be discovered in all things. But to make sensation a basis for an universal method of knowledge, is to rest all knowledge upon an incident—an incident which is in itself unintelligible, until it be lit up by that intelligence which the sensational method denies.

CHAPTER VI.

THE CHARACTERISTIC OF EXISTENCE—SELF-MANIFESTING POWER.

SUCH is the view which we boldly take at the outset, and present to the scientific reader. The Creator being one, and the creation in any one epoch (as, for instance, the present) being one, we admit only one cosmical law, the law of assimilation. If it be asked how possibly out of one law, and such an one, there could arise anything like that endless variety which nature displays, the answer is, that the law operates between two limits, poles or points of assimilation, which are entirely dissimilar, and by two processes simultaneously (analysis and synthesis) which are the opposites of each other. Hence it comes to pass that actual nature is a web in which unity and multiplicity, identity and difference, are everywhere interwoven, and that in such harmony that nature is everywhere beautiful.

The reader will naturally feel that such boldness is offensive; and his feelings we cannot prevent. But we claim as a right that, until he sees more than he has had an opportunity of seeing as yet of our views, he shall suspend his judgment, legitimately asking questions, but not affirming or denying before the time.

And here he may legitimately ask this question, How does the law of assimilation succeed in accomplishing its function when the objects between which it is operating are at a distance from each other in space or in time?

Now, to this the answer is, that it does so simply in virtue of that which we regard as the characteristic of all that exists. And if it be asked what this is, we answer that it is precisely that which the term existence itself expresses. It is the standing-out-ness or self-manifesting power of the object, not merely as anything in general, or as anything different from what it is, but as the very thing that it is. We do not go the length of those who maintain that the whole nature of that which exists is to be perceived, so that an object cannot exist but when it is perceived, its existence being constituted by its being perceived. Existence we regard not as "idea" merely, but as "force." And that force we regard as essentially self-manifesting, or spontaneously radiant, so to speak, into that which is "idea," if there be a recipient of ideas, or a percipient of ideas, or more generally a percipient within the sphere of its action. This view, as it appears to me, is fully borne out by the information of thought itself as to the nature of existence. I find that I can think away all the other attributes of substance; but immediately I attempt to suppose the existence of that which cannot manifest itself in any way, that which is not perceivable by any percipient however perfect, then to me that vanishes altogether—it ceases to be.

Further, while we thus lay the characteristic of existence in the self-manifesting power of that which exists, we do not prescribe any limits in space as to the extent of this self-manifesting power. Thus, it is one of the most certain facts in physics that every atom of this planet, nay, every atom of the planet Neptune, whose distance from the sun is thirty times as great as our distance, manifests itself to the sun, and every atom of the sun manifests itself to every atom of this planet, not, indeed, as a precept, but as the subject and the object of attraction or motion. Nay, by the aid of the æther (which is the grand medium whereby the self-manifesting power of being is enabled to take effect at a distance when other being is interposed), the fixed stars manifest themselves at our planet, though their distances be inconceivably great. We, therefore, prescribe no limits as to distance, beyond which the self-manifesting power of being may not extend.

But it is to be remarked, that the self-manifestation of a remote being or thing cannot but run the risk of being eclipsed, stifled, and lost, when some other being or thing is interposed between that remote object and the percipient. The magnetisms of the terrestrial poles do not manifest themselves to a magnetic needle in the hold of an iron ship. Neither does any distant object manifest itself to the mind of man, unless the intervening æther, the eye, and the optic nerve are acting so as to be transparent, that is, as if they were not interposed. Wherever, in short, substance intervenes, then, in order that the self-manifesting power of that substance may not eclipse that of more remote objects, as, for instance, in order that we may see distant objects, the intervening objects, the æther, the eye, and the optic nerve, &c., must be thrown into such a rhythm as that they shall not intercept the self-manifesting power of the distant objects attended to. Now for this the law of assimilation makes provision.

Distant objects, acting like all objects assimilatively, assimilate the intervening æther and the optic apparatus to themselves, and thus render themselves perceivable. This they do, indeed, only under great limitations imposed by the laws of inertia or motion in space, to which the æther is subject,—limitations which, in man, it requires self-teaching and experience to remove, so that he may perceive the object in its true forms and dimensions.

But this is only man's peculiarity, in consequence of his organic defects at birth, and for a long time thereafter. Those animated creatures which are fit for mature actions at their birth catch the true forms and nature of things at once. They perceive them correctly at once. The chick, for instance, which the day it leaves the egg can leave the cover of its mother's wing, can also run up with the greatest precision to a crumb of bread or to an ant's egg at a distance. And so with all species whose myo-neuro-cerebral system functions perfectly from their birth.

Psychologists, by investigating the phenomenon of perception wholly and solely by the study of a species (man) which is blind and idiotic at birth, and which chips the shells of ignorance of all things only with difficulty and slowly, have necessarily found the theory of perception an almost or altogether insoluble problem. Moreover, even at his best, the embodied mind in man sees objects only very defectively, not wholly as they really are, but only in those few lines proceeding from their surfaces which the laws of inertia permit to be established in the æther,—more shortly, sees them only in perspective. Still, in seeing the perspective of objects, we also see the objects, and that under uniform law. And in virtue of this, it becomes easy, especially when the aid of the sense of touch can be invoked to supply the defects of the eye, to attain to a true perception—such a perception as it belongs to the self-manifesting power of the object to impart at once, were it not for the self-manifesting and, consequently, the eclipsing power of the objects that come in between the object perceived and the mind's eye.

Perhaps, in order to secure a fair hearing, this theory of perception, which is, however, simply a justification of the inexorable affirmations of common sense, would need to be enlarged upon more in this place. But, instead of that, in order to get over the ground still before us, I will only beg the reader not to think either of the percipient or of the object perceived as a point, or an aggregate of points merely, in some determinate positions in space. No doubt, every force has a centre of action; but as to the full extent in space of an unit of natural force as an agent of one kind or another, no limits can be assigned. Consciousness is, no doubt, in the region of the brain. But who shall tell us the boundary in the outward of that power which says I will, I feel, I see? Its modes of acting mechanically are, no doubt, limited to the extent of the investing organism. Nay, in order to their extending even so far, it is necessary that the unity of the organism be maintained by the healthy integrity of the nervous system. In that case consciousness claims all the organism as its domain; and not only when the organism is entire does it refer any pain that arises to the region that is hurt, but after a limb has been amputated, and, when it exists only as a phantom, consciousness still feels towards it as if it were still the old reality. Such is the sustained effect of the previous training of the cerebral part of the nerves which still form part of the unity of the organism—such is the effect of habit, in short, or present assimilation to previous practice. But how far beyond the visible and tangible parts of the body the mind, as a power exerting some kind of action or other, extends, cannot be determined.

And the same of other natural agents and agencies. They have centres of being and of action, but to assign the boundaries of their being and action outwardly is not possible.

Meantime, we conclude that the characteristic of that which exists is this, that it can manifest itself outwardly in some way, as for instance to a percipient as that which is perceivable.

If it be asked more particularly, what is the nature of this self-manifesting power, and what are its effects, it might be reasonably answered that these things need not be determined here, since it is only the existence of the power that is insisted upon. I need not refrain from admitting, however, that our cosmical law, the law of assimilation, must determine, if not the nature, at least the mode of action of this force, for plainly that action must be assimilative. And that it is so, when giving rise to perception, is clearly and distinctly seen; for what is the perceiving of an object, but the mind, as a percipient, assimilating itself to that object? and what is the percept or remembrance of the object which remains in the mind but the idea, that is, the assimilated symbol of the object, which, however, in consequence of the intrusion in the perception of the mind's own activity and of other previously acquired ideas, as also the perspective image, is often very defective as a representation of the reality perceived?

Nay, we may say that this self-manifesting power, which is thus the characteristic of all that exists, is the agency provided whereby the cosmical law of assimilation shall be realised. Let us only add, that as to the intimate nature of that agency it is wholly inscrutable. Nor can it be said to be physical until it is embodied in the æther. In that case it is rhythmical, or undulatory, and formally representative of the object whence it emanates; but with this we have nothing to do as yet.

For the purposes of founding a philosophy, it is not necessary that we should know this. It is enough that we should know that the most intimate and ultimate property, the characteristic, in short, of that which exists, is self-manifesting power. Anything more than this it is not necessary to affirm, nor is it safe, perhaps, if the affirmation is to apply to all kinds of existences whatsoever. But it is worthy of remark that the existence of a self-manifesting power in an object implies that that object is itself a power or force, or an aggregate of such. Now this is enough for the purposes of philosophy and science; and we only deceive ourselves when we suppose that we can think of anything that exists and which is not at the same time a force or power.

The habitual use of our senses, the muscular sense especially, and the structure of all those objects which are around us, all of which have both a determinate form, as tested by the eye or the hand, and an exterior and an interior, of the latter of which we generally know little or nothing but that it supports and defines the exterior, betray us into a demand for substance wherever there is existence, nay, a certain kind of solidity or plenum in that portion of space which is occupied by the object, and this we tend to hold as constituting existence and necessary to it. But a substance which is not any kind of power or force, either active or passive, that which can neither do nor suffer anything, is inconceivable by man. When the term substance has any scientific meaning, and is simplified to the utmost, it is precisely power or force viewed as in a statical condition.

Of most things that exist, therefore, if not of all, let us say that they are capable of existing in either of two states, the dynamical and the statical, and that when viewed as dynamical they are *forces* or *powers*, when viewed as statical they are *substances.*

But what we have here to insist upon is, that when we exhaust or think away the properties of existence, the last which vanishes is self-manifesting power in the object which exists, this property being such, that when it vanishes so does the object to which existence was awarded.

At present, indeed, there is a tendency in the popular mind to listen to those who are for excluding everything that belongs to the sphere of pure reason, and who repeat the last words of the Greek philosophy when about to die, namely, that phenomena only are certain, the laws of phenomena being merely generalisations of thought, and therefore phenomena (of mind). And until this phase has exhausted itself again, as it has so often done already, it is only to be wished that those who content themselves with it, would also keep in mind the other part of the sceptical philosophy; and, with regard to all other things but phenomena, suspend the judgment. In our day, unhappily, instead of this suspension, there is generally denial, and hence a lamentable descent in thought towards zero, with regard to all which it is most important for man to believe.

CHAPTER VII.

CONCERNING THAT WHICH CAN MANIFEST ITSELF TO ITSELF. MIND A WORLD OF SPIRITS. THE REALM OF LIGHT.

The affirmations of the two last chapters—the law of assimilation as the cosmical law, together with self-manifesting power as the characteristic of Being, or outstandingness as the characteristic of existence—enable us now to reach a primary classification of created objects, which we shall presently see to correspond with that which is known as mind and matter, or rather, let us say, mind and that which is not mind; for there is ground for the apprehension that mind and matter do no include all that exists, and that along with matter æther ought to be considered as something intimately related to matter indeed, but yet not just matter. When the elements of the ætherial medium are regarded as truly and simply material, however small and light they may be, the elasticity and pressure which must be assigned to that medium in order to admit of the velocity of light, are altogether out of the harmony of things, and wholly incredible, especially when confronted with the phenomena and the theory of astronomy. Thus, to justify the velocity of light on the same principles as those of sound, in various material media, the ætherial pressure must be 122,400,000,000 times greater than that of the atmosphere! which is incredible.

But what as to mind? To find what shall be called mind, let us suppose an individualised object which is not an isolated object or an universe to itself, but a member in a system, then, in obedience to what has been stated, that object must be at once self-manifesting and impressed by the other objects around it, and, in being so impressed, assimilated to them more or less.

Now, here a most notable difference among objects may occur. Thus some objects, when compared with the others around them, may be so feebly individualised that they shall be impressed or assimilated and fixed in to their very centres, stereotyped all through; others may be so powerfully individualised, that they may be impressed or assimilated to others around them as it were on their periphery only, their centres continuing unimpressed or free. Now, in the former case the object which is obviously self-manifesting to other objects, for it is impressed by them, can only be perceivable. But in the latter case, along with this, must it not, at least while it is impressed externally also, be self-manifesting to itself also? But if so, what is this but to be sensitive, percipient, or conscious? To me the affirmative answer seems wholly satisfactory. Quantity or intensity of substance or power in a monad, then, is the condition requisite for feeling and thought. And thus by an immediate co-ordination of our fundamental ideas of self-manifesting power and assimilative action more or less, we reach a distinct conception of mind viewed in relation with that which is not mind.

Nor have I in this deduction introduced any new element into the reasoning. The primeval created substance, the true protoplasm, is still supposed to be homogeneous, capable of feeling, animated by its assimilation to the Everlasting and the Ever-blessed One. I have only supposed that it is partitioned in varying degrees, so that there are in creation some individualised or separate objects or forces, consisting of so small an amount or such weakness of substance, that they are wholly fixed and merely perceivable; while there are others consisting of so much more that they are free in their inner life, and have power to perceive themselves also—not, indeed, in the centres of their being, and as unimpressed and without ideas, but as members in a system, impressed or assimilated by other objects, and so having ideas, with power to look in this direction or that, and to act accordingly.

Such, then, according to our philosophy, is the nature of a mind or a spirit. It is a being so constituted as to be at once in possession of ideas, and so far fixed, and also in possession of undetermined life or activity, and so far free. These are, as it were, the opposite poles of its being, and the conditions of its activity. If either is wanting, the other vanishes. Without something fixed in the mind, some object of thought or feeling, there can be no thinking or feeling. Without something unfixed, there can be nothing to think or to feel with; much less can there be any thinking or feeling of self, that is, self-consciousness. But grant this condition in the individual, and add the law of assimilation operating first from God above, thus giving reason and conscience, on the higher aspect of our being, and, secondly, from nature around, thus giving observation and instincts harmonious with our situation in the system of the universe, and then human nature emerges.

But human nature plainly belongs to the last day of the work of Creation, rather than the first, where we are now. In man, to all appearance, the organism is the mother and nurse of the spirit. And though the assimilative action of the mind upon the body becomes normally, at least, stronger and stronger as life advances, so long as the organisation retains all its perfection, yet, at first, the assimilative action of the body upon the mind is almost everything. The infant, the child, is little else but the victim of sensations, that is, of assimilations in its mind, effected by the force of external nature including the organism itself. But as the mind, through the sustained action towards the focus of the myo-neuro-cerebral system, which is in the brain, gains quantity or intensity, in one word, energy, it becomes more independent and free, and more able to react out of itself upon the organism in any direction of which it makes choice. But of these things hereafter. (See also Part I. Chap. III.)

What it falls to us to recognise, then, as the first fruits of the creation, such as we have now conceived it, is a world of spirits, the immediate creations of the Ever-blessed One, with no bar between his will and their happiness,—a world constituting a hierarchy, at the summit of which are spirits of the highest order and greatest energy, and at the base, such that they are merely capable of enjoyment, and of no other feeling, save possibly suffering, which is the safeguard of enjoyment.

If it be asked, why a hierarchy, and not all of the same order, all on the same level as the law of assimilation would seem to dictate, the answer is, that, no doubt, we are to expect the whole creation, from first to last, to be in harmony with the law of assimilation; but that law, in its primary manifestation, is not merely the assimilation of all objects to one another, but also their assimilation to the Creator so far as the finite can be assimilated to the infinite. Now, in the infinite, there are two attributes which, to use the language of physics, are, as it were, the opposite poles of his Being, and these (nothing preventing) will impart to his creation the greatest possible variety, while, at the same time, the identity of his being secures analogy and homology in the midst of that variety. These two attributes are the Divine unity on the one hand, and the Divine immensity on the other. And a world of spirits, bearing in its constitution the impress of these two attributes, or assimilated to them, must be a hierarchy, giving, most immediately around the throne of the Eternal, spirits of the highest order compatible with a finite nature, then other spirits increasing in number of individuals as each individual decreases in spiritual power, until those are reached who are possessed of sensibility merely, and can only enjoy or suffer.

And here the question occurs, why should not the partitionment of the true protoplasm, the primal material of creation, why should not the institution of many, instead of one, have been brought to a close before the individual had become so feeble as to be impressible merely, and no longer capable of feeling or of reacting from within itself? The answer is, that the immensity of the Creator, his presence in all space implies, if the law of assimilation is still to continue as the expression of his will, that the created substance shall be diffused to the utmost so as to fill, as far as possible, the whole of space. Now, that substance cannot but be finite in quantity. In being diffused, therefore, to the utmost, it cannot but be attenuated to the utmost. Each particle or element of it must be next to nothing, and cannot but be incapable of any feeling or perception. When the amount of enjoyment in creation has been made a maximum, as is supposed in the question, the primary end of creation has, indeed, been attained; and, therefore, looking to special volitions in the Creator, we might, perhaps, expect a Divine fiat for bringing creation to a close as soon as existence had been awarded to all the possible hierarchy of a spiritual world. But, at the same time, intelligence always expects that the Divine procedure will be in accordance with law, for intelligence itself is a thing of law, and to ascribe to the Deity a volition whose accordance with law does not appear, is to leave intelligence as to that point in the dark. Besides, to assume that if the end of creation was to award existence to creatures who should be capable of enjoyment there ought to be none others in nature, were to assume that individualised objects which had somehow fallen into an apathetic state (as, for instance, by excessive partitionment or attenuation of their substance), could not be recovered or redeemed so as to attain to sensibility again. Now, it is a legitimate inference, that if by an extreme increase of the number of individuals into which a finite quantity of protoplasm has been divided, sensibility has been lost to the individual, then by the confluence again of these same attenuated individuals into unities or monads of more substance and energy, such sensibility should be recovered again. Let us, therefore, take for granted that no stop is put to that development as to individuation which it belongs to the law of assimilation to institute in the primal substances of creation, in virtue of the harmonious bearing upon it of the Divine immensity on the one hand, and the Divine unity on the other. And let us proceed in the same line of thought, and see what we find next. If it prove to be a realm of light as an abode for the spiritual hierarchy which has appeared in this chapter, it cannot be said that in this there is anything in our finding that is out of order. And that there must be such a realm—an universal æther—fully appears.

Thus, in order that the protoplasm of creation may be assimilated as far as possible, and symbolise the Creator in his attributes of immensity, it must, as has been stated, be expanded so as to fill, as far as possible, all space. And in order that it may, at the same time, symbolise Him in his unity, it must be distributed in unities or particles; it must not be a continuous medium—a medium as continuous as possible, no doubt, yet a medium constituted by discrete elements.

Now, it is to be remembered that the primordial substance of creation is finite in quantity. In being all but infinitely expanded, therefore, it must, at the same time, be all but infinitely attenuated. Its self-manifesting power must be reduced to a minimum, that is, it must possess a maximum of transparency and impalpability and seeming non-existence. We need not wonder, therefore, that though such a medium should actually exist, its existence should often be denied. For man's rough way of philosophising is usually expressed in the saying, that "seeing is believing,"—the eye-sight, its focus adjusted so as to enable us to select our food when it is within arm's-length, is made the test and criterion of universal existence!

Further, of such a medium the intrinsic assimilative power of the individualised elements which constitute it must be a minimum. It may be expected that they shall manifest assimilative action only in the lowest degree, that is, they shall possess only the capacity of being assimilated to other objects, and not of assimilating other objects to themselves. This medium must therefore be altogether fitted for representing the other objects which are bathed in it or repose in it, and for carrying out the assimilative action of these objects to a distance.

Moreover, the inertia of the individual elements and of the medium as a whole must be a minimum. When, therefore, two or more objects in space, in virtue of their self-manifesting power, tend to manifest themselves to each other, which would, it may be presumed but for intervening objects, be accomplished in a moment, the delay caused by the putting in motion the particles of this most transparent impalpable attenuated medium will be a minimum. In a word, the velocity of action in it must be a maximum. And, as to the state of mind which this medium, when thus acting between an external object and a mind, should awake, what could we suppose that would express it so well as the gentle sensation of colour carried out on the wings of the belief which the manifestation of the external object awakes in its existence, and instantly applied to the object, so that that object is said to be coloured. This ascription of colour to the object is not altogether a mistake, as over-bold psychologists insist. Colour is of course in the mind only, but so are all other kinds of knowledge. To speak of knowing things in themselves, meaning by this somehow otherwise than in terms of knowledge, is self-contradictory and absurd. Colour, though a more obscure idea than form or motion, is yet a phenomenon of the same order, and is just as legitimately referred to the external object which displays it, meaning by external object something external to the consciousness. Colour is all that we can have in our embodied state as a substitute for a clear and distinct perception of that beautiful dance of the æthereal elements by which the self-manifesting power of an external object reaches the mind. Whether we could possibly have both a clear sight of that dance, and the beauty of the colour at the same time, is an interesting question. I apprehend that we could not. In this it may be thought there would be a loss of enjoyment, and so perhaps there would, but not upon the whole. That loss would be balanced by a gain of enjoyment of a higher order, not in this case only, but in other cases also. For the same reason also (the transformation of mere sensation or emotion into intellectual contemplation), if one could see the structure and intimate action of a neuralgic nerve, the pain would, I apprehend, vanish, the sufferer escaping to behold it as it were from the outside. Yes, the Indian philosophers appear to be in the right when they affirm that all suffering arises from ignorance.

But to return. From what has been said in our pursuit of creation by cosmical law, what we obtain in one grand movement is *a world of spirits dwelling in light with the great Creator in and over all.* In losing thought and feeling, when the created substance is diffused in space to the utmost, we have gained light and colours. In there being no more spirits there has been provided a congenial home for those that are. And nothing, so far, in the whole economy of creation as yet appears to forbid the universal prevalence of enjoyment in all those forms which are proper to adoration, self-knowledge, and a heavenly sociality.

Nevertheless already, as soon indeed as existence was permitted to things unconscious (though, imitating astronomers who speak of the bright specks seen in resolved nebulæ as star-dust, we should call them by some such name as spirit-dust), as soon, in short, as the ætherial elements come in among spirits to fill up the amplitude of space, error became possible, nay inevitable. For the law of assimilation, taking effect in a medium consisting of elements which possess inertia, and which therefore constrain motion to be ever as rectilinear as possible, must tend to reduce a true perception of things as they are, to a perception of things in perceptive only, and thus to substitute for a true perception of them a mere projection of them, which is but a shadow or symbol standing in need of being interpreted before the true perception can be reached. This error, however, though inevitable in the child, spontaneously and speedily eliminates itself as life advances. The external perceptions of human creatures tend rapidly to become as adequate as they are at birth in those creatures whose organism functions maturely from the first. There is nothing in the history of thought that is more curious than that the exceptional process of cumulative observation, or experience which is needful in the human species to make the correction of ocular vision, should have been made the basis, and by naturalists as well as by metaphysicians, of our most advanced philosophy.

CHAPTER VIII.

THE MATERIAL ELEMENT—ITS GENESIS AND STRUCTURE, AND NORMAL MODE OF ACTION.

In what has preceded we have seen the spiritual world owing its being at first to the immediate breath, as it were, of the Creator, then expanding and becoming diffused, as if to emulate the Creator Himself in His immensity, and thus losing itself in constituting the universal æther. As to the actual process of creation, however, all this may have been simultaneous; for the Divine attributes of unity and immensity with ever-blessedness, of which a world of spirits dwelling in light is the image, are simultaneous and from eternity.

But human thought is not capable of the simultaneous at all, and must march in a single file of ideas taking successive steps. In what has preceded, our thought has proceeded from the one to the many, that process which, using the term in its physical sense, is said to constitute analysis. But such a process, being in reality only the half of that of a complete intuition, gives only half views, unless it be followed by its counterpart process, namely, synthesis, which proceeds from multiplicity towards unity, and is constructive of the elements supplied by analysis into unities again. This holds generally; and, as to the matter in hand, we may say shortly that a world of spirits becoming multiple and diffuse, and at last merging into ætherial elements, being now given as the product of the law of assimilation in reference to the *immensity* of the Creator, the same law, when viewed in reference to the *unity* of the Creator, leads us to infer a process of quite a contrary character. It leads us to expect to find the ætherial elements tending to construct unities of greater energy than themselves, and thus to be redeemed so as to recover the spiritual nature.

Now, this synthesis they can accomplish in the first instance by aggregating into groups, each consisting of a number of ætherial elements existing in juxta-position to each other; for if once a portion of the primal substance of creation has been individualised by the operation of the cosmical law of assimilation upon it, there is, at the same time, secured to it by that same law, a true individuality which it must tend to conserve with more or less force. Just as in assimilating themselves to the unity of the Creator the portions of the ætherial medium occupying different points in space became each a unity, an individualised particle of æther; so now, as such, it must assimilate itself to itself in every successive moment of its existence and tend to maintain its individuality. When gathering together into a group, therefore, the ætherial elements, in the first instance at least, will aggregate by juxtaposition and not by confluence into larger monads.

And now the question is, will such groups grow indefinitely, or, when they have attained a certain bigness, will anything occur to arrest their growth so that each shall consist of a definite number of ætherial elements? That the latter alternative must represent the case appears from this, that the ætherial element, being but a minimum of elemental force in every respect, must have but a small amount of self-insulative or self-conservative force. Therefore, under a comparatively small pressure centrad, it is to be expected that the innermost ætherial elements in a group will become confluent into a new unity or monad of greater power. And this new unity must be regarded as a being or thing of an order different from that of the ætherial element.

Now, wherever there is such a group of ætherial elements as we are considering, and which, to save words, we may call a nebular speck, there must be a centrad pressure more or less; for under the law of assimilation all the ætherial elements constituting the group must tend to be assimilated as to the space they occupy, that is, they all must tend towards, or press towards the centre. In each such speck, therefore, a confluence of ætherial elements will tend to take place in the centre: a nuclear monad will tend to form.

Can we then, let us ask, determine the quantity of æther which ceases to be æther, and which is restored to the state of a more powerful monad in this nucleus, as also the mode of its genesis, and its structure? If we can, there is every reason to hope that we attain possession of a secret which will explain the structure and numerical elements of natural objects generally; for the law of assimilation leads us to say "ab ovo omnia" in a far wider sense than Harvey conceived; it leads us to expect a homology in the structure, an analogy in the functions of all such portions and regions of nature universally as do truly correspond to each other.

Now, with regard to the form and structure of the nebular speck which we have conceived, this appears, that so far as is consistent with the centrad pressure, which is inevitable, the speck must be spherical and homogeneous. This the law of assimilation demands in reference to a group consisting of elements which are themselves every way similar, and therefore spherical and homogeneous as the ætherial elements must be. Moreover, it appears also, and for the same reason, that the group of ætherial elements, which constitutes the innermost layer in the spherical group, must also be as spherical as possible, and, at any rate, isometrical.

Now, while various hypothesis and modes of syntheses are legitimate as to the number of ætherial elements implicated in the nucleus, commencing with 4, or an elemental tetrad, and terminating with 2×4 times that number, there are two which the law of symmetry and sphericity, that is, the law of assimilation in its relation to form, present as superior to all others, and therefore to be looked for. They both agree in having 10 ætherial elements in two sets of 5 each for their equatorial region, but they differ in this, that one of them has only one element in each pole, while the other has its polar region filled up by 5 elements for each. In a word, supposing our elastic ætherial elements (all being of equal size) to be so far compressed that they are now bearing upon each other in straight lines, these lines in the one and in the other would defines the following

Geometrical Polyhedrons.

The Dodecahedron.

The Icosahedron.

And here, supposing this to be granted, we are called upon to remark one of the vaticinations of genius. For what was the end and aim of all the labours of the classic geometricians of Greece but to be able to demonstrate the properties of the regular polyhedra, of which these two forms are the chief? Moreover, between these two, this among other beautiful relations has been pointed out as existing, namely, that they mutually circumscribe each other in exquisite symmetry, so that either by overlying the other symmetrically gives rise to a composite structure with a double wall, which is far more perfect than either by itself covering as it were the regions in the other which are naked and open to attack.

Now it follows from the law of assimilation (which as to this matter has been long known to be the law of all chemical and electrical action), that whenever these two, the dodecahedron and the icosahedron, come into each other's neighbourhood, being dissimilar, they must tend to unite and unify. Hence we conclude that a nucleus which may be permanently insulated, and which may be regarded as fully individualised, will most probably consist of 32 ætherial elements unified into one, and be such therefore that, on being resolved, it will give two polyhedra, one consisting of 20, and one of 12 elements or members.

And here let me caution the reader against concluding that this determination is one either of pretended inspiration or of pure imagination, for that there is no evidence in nature as to these numbers and things at all. They have been reached by a survey of nature at first very minute, then more and more general, to which the leisure of a long life has been devoted, till at last it has reached the form of pure geometry. And let the student carry out his studies as he ought to do, if he equal himself at all to the research into the numbers given by chemical analysis and biology, he will find these numbers everywhere manifesting themselves in nature either complete, or, if defective, then by an orderly principle of non-development or abortion. Of these numbers some traces have indeed been given already in our third chapter. If the reader will be pleased to turn back to it he will now so far see the reason of them.

Meantime let him not think the worse of this our radical morphological determination that I have not put this result as an inductive inference. I might have done so; and perhaps such clap-trap might have made the thing popular at once. But I have neither the patience nor the time nor the money necessary for writing the large books which the inductive method requires—books which are, besides, seldom honest. Let us therefore proceed, though in a few words, consenting that they shall be for the future only.

That which we have now obtained, we regard as the material element. It is the product of the centrad pressure in a nebular speck of æther in virtue of which a definite number of ætherial elements become confluent in the centre into one, thus constituting a nucleus of a different nature from that of the uncondensed æther which still surrounds it as an atmosphere, or, as we may say, a dynamosphere, since most of the phenomena of the material element depend on the action of this ætherial atmosphere.

The characteristic which attaches to our nucleus as consisting of a greater amount of substance or force (for, as has been shown, these two terms stand related to each other merely as the statical is related to the dynamical), is that it is competent to observe the law of assimilation in the second degree. The ætherial element itself can observe it only in the first degree; that is, it can only be assimilated to other beings and things, and so represent or image other beings or things. It cannot bring itself forward. But this new element can assimilate itself to itself in its most important relations; that is, in its relations as to space and time, motion and rest; and therefore if this moment it be at rest, it assimilates itself to itself in this respect the next moment and the next, and so on for ever, and thus remains at rest. If, on the contrary, it be in motion, it assimilates itself to itself in this respect the next moment and the next, and so on for ever, and so it continues for ever accomplishing in every successive moment the same element of motion which it accomplished in the first moment, and therefore it moves uniformly forward in a straight line; for an element of motion being the progress of one point to the next point adjacent to it, cannot but be an element of a straight line. Now what is this but the well known phenomenon of inertia, which is the acknowledged characteristic of matter? And such, then, is the principle and nature of inertia in our philosophy. And here I may surely ask the reader whether he has anything else to propose on this head, which has as many claims to intelligent regard? Our philosophy represents inertia neither as a singular ultimate or unaccountable phenomenon, nor as a merely empyrical law, as is commonly done, nor does it invent a ceaseless and universally equally rapid rotation on their axis of all material elements, as has been lately proposed to account for their inertia. Nor does it ignore inertia altogether, as has been still more lately done, throwing back all things into chaos and mystery under the name of force, its laws unknown. Our philosophy merely finds the phenomenon of inertia as one of the thousand consequences of the all-embracing cosmical law of assimilation.

So also as to gravitation. It is the tendency of elements possessing inertia to be assimilated as to the space or place they occupy.

So also as to elasticity or resilience. It is the inertia of form, the tendency of an individualised form, when it has been disturbed, to redintegrate or assimilate itself to its previous form. And here we may remark again in passing, that elasticity, or the restoration or reproduction of form, must render the acting law of assimilation to be secular as well as momentary. And thus, then, are explained also all the phenomena of habit, heredity, atavism, &c.

But elasticity is possessed in perfection only by the material element itself when it is fully invested by its original complement of æther. The material element itself, therefore, is the only species which is wholly intransmutable. And even the material element, in common with every individualised object which has had a genesis and history, must during eternity be liable, under the law of assimilation, to be resolved again into the æther out of which it was constructed. Not but this regressive operation of the cosmical law, this tendency to reversion, may be met by the unifying and unity-preserving operation of the same law. These two are everywhere co-ordinate, and, in certain cases, either may possibly prevail as the will of God may determine. Nor can the forthputting of that will at any moment or in any region of space be viewed as exceptional or out of the field of science. There is no ground in the nature of things for that contrast of which one hears so much at present under the several designations of the natural and the supernatural. The Divine will is, indeed, now permissive, now imperative. But if by natural is meant that which occurs all independently of His will, either way, then, there is no such thing. Then all is supernatural. Then the economy of nature is one sustained miracle—constant, uniform, and familiar indeed, because the forthputting of the Divine will is one and the same thing with the operation of perfect intelligence, and such intelligence will not vary in its judgment as to what is to be done when the conditions of existence are the same —but still it is all miracle, if by miracle be meant merely the manifestation of Divine agency.

To ascertain the quantity of æther or the number of ætherial elements involved in constituting one complete material element is quite hopeless. But not so hopeless is it to discover the mode of action normal to the ætherial atmosphere, or at least that portion of it which corresponds to the nucleus; and this is more important. And here, happily, there is a familiar electric experiment which will serve to illustrate, though rudely, the normal action proper to the ætherial atmosphere of the material element, when there is no other limitation to its existence but that itself exists, and is called upon to act in a medium which is in some respect dissimilar to the nucleus.

The experiment referred to is that which bears the name of the electric spider, which we may conceive to be thus exhibited. Let there be a metallic ball, standing up from the prime conductor of an electrical machine, and let it be enclosed in the centre of a spherical cage placed in connection with the rubber, and composed of gauze wire or otherwise, so as to allow the spectator to see any action which may take place within. And into this cage let a number of small pith balls be introduced. Then, on exciting the electricity in the usual way, the metallic ball being first rendered dissimilar to the other parts of the apparatus as to electrical state, the pith balls will rush to it, and for a moment adhere to it. But becoming speedily assimilated to it, they will adhere no longer, partly because, in so far as electricity is concerned, they are now entitled to assert independent existence, and partly because, in being assimilated as to electricity to the state of the prime conductor, they are rendered dissimilar to that of the rubber, and consequently to that of the surrounding cage, which is in connection with the rubber.

They will therefore fly off from the ball or nucleus to line the cage or surrounding medium. But then, again, being assimilated there, they will fly back to the ball or nucleus of the apparatus. And similarly from that again back to the periphery; and so on. They will thus maintain a radiant and returning action between the nucleus and the ambient as long as electric difference between them is maintained. Moreover, if we conceive that the metallic ball presents to its atmosphere of pith balls, distributed symmetrically over its surface, twenty regions or points, as also between or beneath these twelve other regions or points, these two sets of points being simultaneously dissimilar as to electrical state, we shall then have twenty and twelve of the pith balls in opposite phases of motion at the same time. Nay, more, in that case we may conceive the cage to be dispensed with altogether, and each pith ball to perform an excursion with return to a point near its origin in the ball or nucleus,—that is, each to perform an orbit which is a very eccentric ellipse, their major axis a continuation of the radii of the central ball or nucleus. Thus would that nucleus be surrounded on all sides by a structure in most rapid motion, more light or ætherial, and more transparent or hyaline than itself. Something of this kind we conceive to be a rude representation of the mode of action of a certain number at least of the ætherial elements which constitute the atmosphere or dynamosphere of our material element. And if this material element thus acting could only be rendered visible, would it not be at once pronounced to be the spore or ovum of some zoophyte or sponge or sea-weed, surrounded by cilia? But let us not anticipate; rather let it not be forgotten that we are now at an incredible distance from everything that is visible. The interior of the white of an egg, under the highest powers of the microscope, is perfectly hyaline, structureless, and invisible, and yet in a single atom of albumine there are certainly not less than 18,000 of the material elements or units of atomic weight, whose structure and normal mode of action when free we are now investigating. The microscope is no doubt an assistance to the naked eye. But the step which it enables us to take in the direction of the intimate and ultimate structure of nature, compared with what is required in order to full insight, is so small as to be scarcely appreciable. The true histology of organisms is one thing, and their microscopic anatomy is another. Nevertheless, as has been already stated, the universal dominion of the cosmical law of assimilation secures a certain amount of homology in structure and of analogy in function universally. And what is seen by the microscope, if accurately observed and rightly interpreted, may be taken as a sample of what exists beneath in the region of the real and the invisible. And if we find that a form and mode of action which, without the slightest reference to the microscope, or indeed to the use of the senses at all, has presented itself to us as a product of rational deduction from experiment or theory, presents itself also among the first individualised objects visible under the microscope, this is certainly a verification, or at least a good commencement of a verification of our views. No doubt our cosmic protoplasm, being wholly homogenous and undifferentiated, is eminently different from the visible protoplasm of the biologist, which resolves itself on decomposition into oxygen, hydrogen, nitrogen, carbon, &c. But we shall afterwards find that it is the mother and nurse of the latter. And that there should be first a simple and homogenous protoplasm, and afterwards a differentiated protoplasm, heteroplasm, or deutoplasm, or biogenitic substance functioning similarly, but more composite in structure, is just what the homology of nature leads us to expect.

I have stated that our material element, with the rapidly moving particles of its ætherial atmosphere functioning normally, could they be rendered visible in the microscope would be affirmed to be a spore or ovum, completely surrounded by vibratory cilia. To this I may now add, that if, as in entozoa, or in the mass or tissue of an organism, they were so confined or crowded together that there was no room for the play of the cilia, they would then be regarded simply as nucleated cells, that is, as individualised bodies as spherical as their surroundings permit, consisting of a more hyaline or transparent body, and a more opaque nucleus.

In order to obtain the radiant and returning action in the ætherial atmosphere of the material element which has been described, we have supposed that the ambient medium in which the material element exists is simply dissimilar to the nucleus of the material element. Now it is to be remarked, that the action described tends to assimilate as to state the ambient medium and the nucleus; and when the action has been long continued, that assimilation must take place more or less. But of this the result must be a resistance on the part of the ambient medium to the excursions which the ætherial elements tend to make from the nucleus in a radiant manner. And now let us ask what must be the effect of this resistance on the form of their excursions?

Here two cases present themselves. First, the resistance outward may be of the same amount all round the material element, while, at the same time, the force repelling the ætherial elements from the nucleus is also of the same amount all round. Now in such a case it appears that the effect must be to poise the ætherial elements at a certain distance from the nucleus, so as to construct around it an ætherial shell, thus giving an anticipation of a simple cell with a nucleus according to the original conception of it,—that is, with a cell-wall as well as a nucleus and with protoplasm for an upfilling.

Secondly, if the resistance on either side be not in equilibrio all round, then the radial action must be transformed into spiral. And thus, according to our theory, there is introduced into nature that other kind of form which, along with the sphere and the straight filament, appears so early, namely, the spiral or wriggling filament in connection with a mass or head when it is complete, that is, the form of the spermatozoon, &c.

To analyse the action and determine its morphological product in this case is beyond our power. But if the material element be unsupported by others, this wriggling or spiral action must tend to partition it. And if it partition it symmetrically in reference to all the dimensions of space, and in the simplest manner possible, it would break it up into four individualised objects, each with a spiral or wriggling tail, and a head consisting of $\frac{32}{4} = 8$ elements, constituting an unity which might be said to consist of æther on its way to matter. And this may perhaps be admitted to be not a bad ideal of that mysterious element by the development of which the male sex is characterised, and to which such intense interest attaches.

Here, then, we see how an individualised object which has completed itself, and attained to the spherical in form and structure, may continue to exist by partitionment (as also possibly by aggregation), and take a fresh start and commence a new cycle of activity again.

And by considering a combination of the two we obtain a theory of impregnation. The unimpregnated ovule or ovum is a product of most mature action and an eminently spherical structure. It is therefore well suited for repose for any period of time, in the ovary of the parent, or wherever it may have been constructed. But when a form with a defective head and a spiral or wriggling tail (an antherozoon or spermatozoon) comes in the way, as it must tend to do, its form being so dissymmetrical and consequently so active; then these two, the ovum and the impregnating element, being so dissimilar, must tend to unite with force and interpenetrate, and so to disturb the symmetrical and reposing structure of the ovum and introduce a dissymmetrical part instead—a part which must, however, as an ovum continue to mirror the maternal genesis, and as changed by the impregnating matter of the male, must also mirror the paternal genesis, and which, therefore, during that evolution on which its dissymmetry insists must represent both parents.

There is yet another case as to the ambient medium which requires to be taken into account by us. In a word, that medium may be concrete as well as fluid. The material element hitherto free may, for instance, come into contact with the wall of the containing vessel, as a spore, &c., or may fall to the bottom or adhere to some neighbouring solid. What then, let us ask, will be the mode of action which will ensue in our material element in such a case? To this the answer plainly is, that if the concrete with which it comes into contact be in a similar state with itself it will spring off from it and regain its liberty and normal mode of action again. But if the concrete be in a dissimilar state, then the ciliated or tentaculated form will adhere to it. And the ætherial elements on the side of contact, instead of continuing to play in excursions to and fro, as formerly, will take on the character of root or foot, while those only on the opposite region will continue to act freely. And have we not here the type of the ciliated spore now settled in order to commence development as hydrozoon, sponge, or alga?

Now, while it is developing, the law of symmetry and sphericity, however much resisted by hereditary structure, adhesions or incident forces, must still be operating. As growth and development proceed, therefore (1) a constantly recurring tendency to individuation must manifest itself, the object as it grows must tend to grow multiple or to be a community; and (2) this tendency, when aided by the law of symmetry, may often succeed in disengaging from the growing individual, symmetrical animated portions having the aspect of completed individuals, though not really so. Now of this is there not a beautiful illustration in the production of medusoids? &c. That the same individual should prove to be multiple sucessively instead of simultaneously, and polymorphous as to type, and in successive epochs of its existence stand still without change of form for a time, the individual thus simulating several individuals of various orders, and exhibiting what has been called "alternate generations," is not wonderful. It is merely a serial manifestation of that variety which nature usually displays simultaneously and co-ordinately.

But here we are postulating growth and development for which the necessity has not yet arisen, nor has any provision been made. Let us not, therefore, proceed in this line any further at present, but rather enquire what functions of animated nature the action of the material element itself prefigures and under the law of assimilation must determine. To find a place for growth we must have a composite body, and not a single material element to start from; and to have development in the systematic or specific sense of the term at least we must have an ancestry of some kind.

CHAPTER IX.

OF ELEMENTAL RESPIRATION AND EXHAUSTION.

The material element, as it has been conceived in the preceding pages, is, on the principles there advocated, a very perfect thing. It is isometrical in form, and therefore fulfils already the law of symmetry so that no continued action of that law will induce any change upon its form. And yet it is differentiated in structure, so that it is preserved by the law of differentiation (the maintainer of the concrete state) from that tendency to partitionment or dissolution which belongs to the isometrical when it is homogeneous. The material element, therefore, possesses the morphological conditions requisite for its continuance in existence for the greatest length of time.

Still that length of time, however great, can only be a very long time. The material element having had a beginning in time cannot spontaneously exist for eternity. For, whatever its solidarity at the present, or at any moment, a thing which consists of particles which were once discrete, must, under the law of assimilation acting in relation to time, and known as the phenomenon of reversion, be liable to resolution into its primordial elements again. Whenever, in reference to such composite being or thing, an analytical phase of existence prevails over the synthetic, that being or thing must tend to repeat its previous history backwards, and to be resolved into its previous elements.

And so with the material element itself. And in this perhaps there may be the cause of phenomena which are at present a mystery in science. Thus if the analytic phase of action were to overtake the material element suddenly, as by some rapid change of situation or of heat or of electricity, &c., then in the lighting up perhaps for a moment of a speck of phosphorescence with an inaudible explosion, that element would resolve itself into the matter of light again. And if this were to happen on the great scale, in the upper regions in connexion with our globe, then possibly in the absence of sun-light faint meridional or equatorial lines of light such as those of the Aurora might be seen even by such eyes as we possess. And in the celestial spaces there might possibly be phenomena like those exhibited by comets' tails. If again the analytic phase of action were not sudden but sustained, then there might be expected the slow vaporisation of the nucleus of the material element into æther, having its issue in the complete disappearance of the nucleus. And thus there might be phenomena of which we are reminded when we think of what happens to the nucleus of a comet when near its perihelion, or to a living cell when its function is nearly being completed.

But this case calls for a more special consideration. We have seen that, in all but a single instance, the material element in virtue of its normal action must be subject to a nucleus-attenuating action which must be regarded as quite normal to it. The exceptional case occurs when the medium in which the material element exists is of the same nature as the nucleus of that element. When that is the case, then indeed the ætherial particles constituting the dynamosphere of the material element, after having been charged under the law of assimilation with a material aura by their descent upon the material nucleus and contact with it, and after that descent and contact repelled by it in virtue of having been assimilated to it, will, after having completed an excursion to a certain extent outwards from the nucleus, experience repulsion from the medium beyond also, that being also similar to themselves. And thus they will be balanced there by a repulsion both from the inside and the out, and so they will form a materialised spherical ætherial shell or cell around the nucleus. The material element as to its natural quick action will be brought to a state of repose, and, as we may say, it will be encysted or exist in a state of hybernation. And here are we not called upon to observe the prefiguration of phenomena of the same nature in the animal kingdom, which have indeed been already noticed? But what we have now specially to remark is this, that in this induction of the encysted or hybernating state there is neither new life nor loss to the material element. That element is as strong and is indeed all that it was at first, but it is no stronger nor more. It merely exists in a state of tension representative of the previous action which threw it into that state.

But what if the ambient medium be non-material, which is the fact. In this case plainly the state of tension induced in the material element must be relieved. The particles constituting the shell or cyst of the hybernating or encysted structure being now dissimilar to the medium beyond, will impart their material change to it; and being thus rendered truly ætherial organs themselves, they will descend upon the nucleus whence they had been raised, and the initial state will be restored. And now receiving from the nucleus a material change again, they will be thrown off as before. Of this charge again being relieved by the non-material medium beyond, they will descend upon the nucleus as before; and so on, fulfilling the reciprocating action which was described in last chapter. Here then we see, looking to this action so far at least as it has been described, that it must be exhaustive of the material character of the nucleus; for every successive excursion of the ætherial elements which constitute the dynamosphere of the material element carries off into the ambient medium a material aura, while nothing of the kind comes down in return. The longer this action continues, therefore, the more must the nucleus of the material element, considered as a materialised organism, be attenuated. In what way this secular attenuation of the nucleus of the material element shall manifest itself it is not easy to discover. It can scarcely be otherwise than in a relaxation of that unity and confluence of the ætherial units constituting the nucleus which makes them to be non-ætherial or material.

But before forming conclusions as to this matter it is necessary to call to mind that the action of the law of assimilation is always reciprocal. If the ætherial elements in their excursions from the nucleus of the material element impart a material charge to the medium or region beyond, that being of necessity such as to be a recipient of such a charge, it is to be remembered that the same elements in their descent upon the nucleus must impart to it in return some kind of equivalent derived from that region beyond. Now, what can this be? It has already appeared that it must be non-material. Is it then merely and purely ætherial? What, if all the æther in the celestial space considered is already appropriated as belonging to the material elements which possibly crowd that region, is there nothing above and beyond, that can help us out of the conception of a broken or half fulfilled law? What is wanted to fulfil that law is the existence of a power or energy above and beyond the æther or medium of light of a non-material nature, or rather of a nature existing in contrast with matter. What then can it be? To call it immaterial or spiritual would be merely to introduce terms which are at present voted to be unscientific. But this is certain, that by whatsoever name it be called, it must be a power or energy, for nought else is conceivable by us as capable of an objective existence. Let us content ourselves then with saying that, in exchange for a series of losses of its materialism, by the unceasingly reciprocating action of the ætherial elements of its dynamosphere, the material element is all the time receiving from beyond and above itself corresponding accessions of non-material energy or power. And with this the mere physicist, if he is determined to continue such, must be contented as a last word. His distribution of the sciences, and his proposed isolation of physics from all that is above and beyond, calls out "stop" to the train of thought if it ventures on the next word, for that word belongs to the sphere of theology. Nevertheless, let it be stated here that this sustained supply of non-material energy which, it thus appears according to our views, inflows into the material system from above and beyond the ætherial medium or realm of light, is and can be nothing else than the sustained operation of the ever-acting will of the ever-living Creator of all, not in word, but in power, at once natural and supernatural—*natural*, inasmuch as the exclusion of mistakes and of all need for alterations and improvements implied in His perfect intelligence from the first, gives rise to uniformity in phenomena when the conditions of existence are the same along the whole stream of time; *supernatural*, inasmuch as the whole material system is, according to this view, not wholly self-contained and dependent on itself alone—not merely a timepiece inexorably unwinding and winding up itself again mechanically without the possibility of any departure from what was set at the beginning—not a finished web in a show-room, but a web still in hand, still in progress under the eye of the designer. Hence follow the doctrines (1) that there is both a general and a particular providence; (2), that prayer for physical change is not unreasonable, and may be granted without what is commonly called miracle; and (3), that what history records as well-attested miracle may enter into the normal or scientific conception of the material economy.

But to return to the purely physical conceptions of this chapter and the preceding, have we not, let us ask, in the normal reciprocating action of the dynamisphere of the material element, and the continued ascent of something material from its centre or interior to the ambient medium above and beyond, and the descent from that medium towards the centre or interior of the material element of something of an opposite nature—have we not in this, let us ask, a striking prefiguration of the functions of respiration as it actuates the whole animal kingdom and ourselves? Thus an animal, in so far as it consists of living matter, may be regarded as an aggregate of aeriform particles retained in the concrete state by the fixing power of carbon, which is one of the most fixed of all the elements, and as we may say, the most eminently material.* Considering an animal then as primordially represented by

* Those readers who are acquainted with the previous parts of this work (P. II. p. 67, P. III. p. 74) will grant how suitably among all elemental molecules carbon may be chosen as the representative of what is pre-eminently material, and how curiously an atom of diamond may represent the nucleus of the material element itself, as it has been here conceived. Thus it has been seen that, according to our views, that nucleus consists of thirty-two ætherial elements confluent into one. Our method which enables us to deduce the specific gravity of solids, and when

one material element, the carbon in that animal will represent the nucleus of that element. Moreover, though the animal, as a whole and to the eye, seems a concrete, yet it is well known that in every case of life there is, and in order to life there must be, a sustained interchange of dissimilar particles, one set coming in, as we may say, the other going out—not dissimilar, indeed, when reduced to terms of greatest simplicity. In their ground these particles are both the same. Oxygen is the moving element in both cases, but with this difference, that, when going out from the animal, instead of a merely material aura, which is the charge of the ætherial element when going out from the nucleus in the single material element, the oxygen in this phase of its action, when leaving the respiratory apparatus, is charged with carbon; while previous to its descent again, or the returning phase of action, it has recovered its previous quickness—a quickness which has gained for it such names as vital or empyreal air. It has, in fact, in the meantime deposited its carbon in another medium outside the animal kingdom altogether, giving to nature the vegetable kingdom or adding to it.

Here, then, we are now able to understand fully the necessity of sustained respiration in order to the continuance of animal life. The fact has been known time immemorial. It has also been known for long that respiration removed carbon from the system, and that it was this element which, if left in it, speedily produced death. But it was not known why carbon if thus left should prove so speedily fatal. And here let us state that reason which now appears, as it may sometime hereafter lead to a complete theory of poisons. The function of carbon in the organism is to bolt the aeriforms (common and ammoniacal vapours) together, and so far to fix them as to prevent life from being quite ephemeral. But while it holds some particles, it must let others go, for life implies a continual exchange. To be wholly fixed is to be dead. Carbon, the fixing element, therefore, when in excess in the organism in that state (probably of single atoms) in which it fixes, must make for death, and when in excess in the "nœud vital" must destroy life.

But respiration not only carries off the effete and poisoning carbon atoms. In doing so it generates such heat as the renovation of the

that has been ascertained by the balance, to deduce from the experiment the structure of the molecule, leads to the inference that the least atom of diamond consists of just thirty-two atoms of carbon (the same being the case with other fixed or reposing substances, such as gold and silver). Thus forming these atoms of diamond into the usual dodecatomic molecules to bring the unit volume of the substance into relation with the aqueous standard, we obtain—

$$\text{Expt. Diamond G} = 3{\cdot}55 = \frac{30 \times 32 \times 12}{2 \times 1620} = \frac{\left(\frac{32}{C}\right)^{12}}{2AQ} = 3{\cdot}55 \text{ Theory.}$$

organism requires. It gives moisture also to the tissues. In a word, it does more for us than can be told.

But it is to be remarked also, that while respiration is a vitalising and an energising process, it cannot but be also an attenuating and an emaciating process. If the concrete state and a certain mass of organism be essential to the well-being of an animal, as we know it is, then respiration brings with it an evil as well as a good, for it is always carrying off matter from the organism. How then, let us ask, is this good retained, while the evil is met and superseded? Plainly the evil will be met, if the matter breathed away by the animal can be reduced to the concrete state again, in such a form that it may feed respiration anew, and thus render this function continuous and circular. Now this is precisely what is done in the economy of nature. The vital or empyreal air of the atmosphere, after having been breathed and charged with the carbon of which it has relieved the animal, and now bearing the expressive name of choke damp, retains so much of the fixing character of carbon and the parasitic nature of oxygen, which are its constituents, that it tends to settle on the surface of the soil and on the foliage of plants, and to give up its carbon there to perform in the vegetable kingdom the same function as it had already performed in the animal kingdom, that is, to fix and to build up into somewhat stable tissues, particles whose cohesion otherwise would be wholly ephemeral at all but the lowest temperatures. Now these vegetable tissues, when not too stable, are such that animals delight in taking them into the interior of their bodies or stomachs, and there they are assimilated to their tissues. Thus is the attenuation inevitably attaching to respiration beautifully remedied. Nor is there any want of vital air to carry life on as before. The breathed air having given up its carbon to the soil or foliage, is now vital air again, and resumes its place in the atmosphere as fit as ever (at least after a dance in the sunbeam), for descending on or into the animal and enabling it to breathe.

Thus is the vegetable kingdom co-ordinate with the animal kingdom, and its complement. The two taken together, with the atmosphere around, and the sunbeam playing upon both, form a complete self-sustaining circle. But the fact that animals and respiration existed before vegetable matter required that animals should be so constructed that they could feed upon each other also; and hence, manifold complications. Moreover, ammoniacal vapour, which is no less essential than common vapour to constitute living tissue, when it encounters loose atoms of carbon, and undergoes decomposition, is not capable of the aeriform state. Hence, to the respiratory system, an ureal system required to be added. In all food also, there are some unassimilable parts, and hence a fæcal system was also required. But these facts do not belong to the intention of the creation, but to the inevitable limitations under which alone any design could be carried out which involved the existence and action of forms and forces in limited portions of space and time. The material element itself is rather a foreseen and a divinely regulated thing, than a freely willed and primary creation. Spirit, that which is capable of thought and feeling, is the original and elect object. Body, that which is wholly apathetic, is rather of the nature of a chemical precipitate in creation, giving grand and beautiful phenomena no doubt, and therefore sanctioned, but still as compared with spirit, only a cloud in the azure.

I cannot conceal from myself how completely these views stand in contrast with all that is currently believed at present by many to whom the name of scientific on the one hand and of religious on the other is accorded; and, of course, I must take kindly the disapprobation of both. How many hold at present that some one dead thing called "matter and force," acting blindly and only mathematically at first, is the sum of all reality—thought and feeling being merely a transient efflorescence of "matter and force" when it has come to exist in a certain state, nervous ganglion, namely! Now, to such a scheme of the universe, the views here advocated stand diametrically opposed, and are indeed its complete inversion and denial. From philosophers of this school, therefore, these views will receive no quarter, and as the kindest treatment will be ignored as long as possible. Nor will they be more congenial to many religious men who simply take for granted, without consideration, that the Divine omnipotence implies power to realise or substantialise immediately and independently every idea be what it may, provided only it be not essentially contradictory or self-destructive. But plainly such a conception of creation, in order to be accurate, requires to be specialised. Existence implies all its conditions. That which is to occupy limited portions of space cannot but have a form of some kind. It must therefore fall under the conditions which the science of form, geometry, imposes. Not that this science is anything that exists absolutely or adversely to the Divine power. On the contrary, in so far as it is true and perfect, geometry is merely the expression of the Divine power acting as intelligence when contemplating limited portions of space and time, that is, when looking into a field which is also its own, and without which it is not possible to conceive how it could be at all; for space is not what an over-keen analysis gives it—a merely subjective phenomenon, a dissolving view. Space is the eternal co-ordinate of the omnipresence of the Deity, objective as well as subjective; and man owes his subjective hold of it, as usual, to the cosmical law of assimilation.

CHAPTER X.

OF ALIMENTATION—ITS MODES AND UNAVOIDABLE LIMITS.

If the material element was brought into existence by a process of development, a process which took time to accomplish, and that, the synthesis of particles which previously existed separate and individualised, then under the cosmical law of assimilation acting as to time, that is, the familiar law of reversion, it must be liable to resolution into its ætherial constituents again. In the preceding chapter, indeed, the function has been shown by which this law will be fulfilled, and by which the material element must tend to repeat its own history backwards, and suffer dissolution—or rather, let us say—be resolved into that more perfect state of being in which it existed previously, namely, pure æther or the matter of light.

But we are not to infer from this that the material universe contains in its own nature the seed of its own extinction. Those ætherial elements which have once entered already into the structure of a material element must, though now existing separately, tend, when the ebbing of the analytic force allows, under the same law of assimilation, to reconstruct a material element again. And thus in different regions of nature the dissolution and the genesis of matter will be concurrent and equivalent, and the quantity of matter or of force in the universe as a whole will be conserved, as Leibnitz long ago maintained, and as modern physicists have made some feeble attempts to demonstrate.

Such, then, is our conception of the material element as to durability. It is naturally very long lived, but it is not naturally everlasting. In fact, already even in the material element itself the periodicity of nature has commenced. In the cosmical law when viewed as acting in time upon that which lives and moves and has its being in time, the dissolution of the body of the individual and its reconstruction or resurrection are already preluded.

We have seen in the last chapter the mode of action—preluding respiration—by which the nucleus or body of the material element is attenuated or emaciated and brought towards dissolution. And now, let us ask, Does the economy of nature present us with no equivalent action which shall be correspondingly conservative of the individual? While breathing away its substance into the ambient medium, does the economy of nature present no alimentary provision? Yes; this also the same cosmical law provides. As soon as protoplasmic organisms of dissimilar ages, though otherwise identical, come into the same field, those which were there before, and have lived longest in it, must go to those which have been more lately introduced. For in proportion as they have lived longer they have breathed longer, and so been rendered materially weaker than the younger ones. But in being rendered weaker they have at the same time been rendered dissimilar. In virtue of their dissimilarity, therefore, the two will, under the law of assimilation, tend to unite. And the mode of their union must be this, that the weaker shall succumb to the stronger. The stronger shall assimilate the weaker more or less, and so feed upon it. But here three modes of feeding present themselves, which, according as the one or the other takes place, must be productive of very different phenomena in nature.

I. The dissimilarity between the two individuals which leads to their approach, may be such that their union is only a transient concurrence, and results not in their complete reciprocal assimilation and their unification, but in the construction between them of a reciprocally assimilated morsel, ovum or embryo, which ultimately separates and sets up in nature as a representative of both. The feeding in this case is that implied in sexual function.

II. The dissimilarity between the two organisms or cells may be such that, after having met in juxtaposition, one or other, or both, are no longer capable of maintaining an individualised and separate existence, while yet neither is so powerful, compared with the other, as to assimilate it entirely and absorb it into itself. Hence there result in this case not the genesis of ova and embryos, but the growth, composition, and differentiation of organisms, and in fine, under the laws of morphology, all the variety of species in nature which enter into the original design of the Creator, as embodied in the material element itself.

III. The dissimilarity between the two may be such that the one is powerful enough completely to appropriate the other, to digest, and to assimilate it, adding it in separate particles to its own organism whenever such particles are wanted for redintegrating its organisation, restoring its energy, and rendering its life enjoyable. In this case, then, we have a supply of food and alimentation as commonly understood.

Now, in all this there is, I apprehend, nothing that is calculated to disturb theodicy. On the contrary, is there not very much to admire, and for which all nature, so to speak, should be thankful? This must, I think, be frankly admitted. But if so, then there is no room for insinuating intellectual or moral dissatisfaction with things as they exist in nature, when nature is regarded in a theistical point of view. There is no room for apprehending or insinuating that nature cannot be the creation of a benevolent Being on account of that struggle for existence which nature undoubtedly displays, and the fine organisation of the carnivora and other feeders on animals. That there should be a struggle for existence, shows that existence is felt to be a desirable thing, or a good, and so far, therefore, the gift of a good Being. And as to feeding upon animals, and no doubt depriving them of their life in doing so, how could it be otherwise, since food must be had, and as yet, according to our conception of nature in its rise, there is nothing but protoplasm or animal matter to feed upon? If it be suggested that some animals might have been made to feed upon other animals without killing them, this is to advocate the substitution of epizoa and entozoa instead of free animal-feeders, which few would be disposed to insist upon as an improvement. If it be asked, why all animals might not have been made to feed upon earth as many worms seem to do, it must be remembered that as yet, when a sentient creation as a maximum had to be designed, there was no place for earth, though it had been possible to make animals such that they could assimilate earth.

But why, it may be said, were not all animals made so as to be vegetable-feeders? To this the answer is, that according to our conception of the cause of creation this was impossible; if creation is to teem with a maximum of sentient life from the first, vegetable life can only be subsequent to animal life. And that it really is so, the actual observation of nature, even in the present epoch of nature, fully verifies. It is quite in vain to look for vegetable food to sustain the animal life with which the depths of the ocean are now known to be carpeted, or infusorial animalcules, or indeed the animal kingdom anywhere in its rise. Besides, the structure of the living vegetable element, the primordial article, shows that it is more highly elaborated than the protoplasmic animal cell. It is as perfect and it has something superadded, namely, a casing of cellulose—an advance in organisation, and a provision which may be compared to the siliceous and calcareous shells superadded to many simple animals. More than this. According to the theory of creation here advocated (which has it not this also in its favour that it gives a very definite relation between the animal and the vegetable kingdoms), material for the construction of a vegetable kingdom does not exist until animals shall have breathed, and lived, and died previously. To give being to a living plant, not only aqueous and ammoniacal vapours, but carbonic acid gas is wanted. And in that golden age of planetary condensation which we build upon, when the "cosmic vapour" was condensing so gradually that the organic elements only were being constructed out of it, but nothing mineral, or volcanic, or fiery in any way, when, in a word, all was favourable to animal life, it was from animal life alone that carbonic acid gas could be obtained for vegetable life. As to the ammoniacal vapour, which is no less essential, we ascribe to it a direct genesis out of aqueous vapour, as shown hereafter.

Here, let us remember, however, that an epoch of condensation did arrive when the more central parts of our planet became meteoric, volcanic, and fiery, and then no doubt, as now to a certain extent, carbonic acid gas would be generated in a mineral way. But this state of things may still be regarded, not as the triumph of death over life, but rather of life having its revenge upon death; for during this epoch, carbonic acid gas in all probability must have been evolved very abundantly; and to the very extent that this gas was then or is now given to nature, it creates a saving of sentient life; for it goes to construct vegetable matter, and so to supply such food for animals as shall not necessitate the destruction of other animals as food for the survivors.

Very beautiful is the adaptability of carbonic acid gas (along with aqueous matter) for returning to the animal kingdom, to which itself normally and originally belongs, all that the animal kingdom needs for its existence. Having already been concreted, it is under the law of assimilation (reversion), prone to become concrete again, a tendency which on its very discovery gained for it the significant name of "fixed air." When thrown out of animals during their respiration, accordingly, it tends to settle on the ground, or on the foliage which has sprung out of the ground. And there it is parted into its constituents. Its oxygen is restored to the atmosphere to serve for respiration again, while its carbon is taken in to serve as bolt and screw for the particles of aqueous and ammoniacal vapours present where it has been absorbed, which when thus bolted and screwed together constitute vegetable tissue. Now this vegetable tissue does not exist for the sake of its beauty only, though that be so great as to secure universal admiration, nor yet for withdrawing from the atmosphere the products of respiration which, if they had to be breathed again, would prove injurious to animal life. The vegetable tissue is, as has been stated, good for food. That which, if it had been left in the state of "choke damp" diffused in the air, would soon have proved fatal to animal life, is, by being split open and having its oxygen returned to the air, and its carbon fixed in vegetable matter, rendered most valuable to animals both ways. It both supplies air for respiration and food to repair the emaciation which respiration unavoidably implies!

And thus a benignant economy in favour of sentient life appears. At first animals must destroy animals for food, for food is indispensable, and there is none other as yet but animal food to be had. But as the animal lives and breathes (which are the same) it puts forth leaves, not on its own body, but elsewhere in situations more convenient for bed and board as well as shelter. And the more there is of breathing or animal life in nature, the more there tends to be of foliage, to produce which, moreover, the expiration of the volcano co-operates with that of the animal.

The course of nature, therefore, as to alimentation is this, that while at first carnivorous practice in animals is inevitable, yet these very animals, by subsisting on animal food, give birth to vegetable food, which thus tends to increase in supply as the ages roll on. Thus, in the limit, what we foresee throughout the entire zoological scale are vegetable feeders only, all destroyers of sentient beings having vanished.

The real struggle for existence then, when the economy of organisation is regarded in the largest point of view, is between two orders of beings, which we may respectively designate the lung and the leaf—a friendly struggle in which the destructive defeat of one is in reality the signal victory to both, the leaf in yielding to the lung, affording it "bed and board, coal and candle," and phœnix-like, speedily arising again from its own ashes, more beautiful than ever.

But why, it may be asked, this round-about method of alimentation? Why these long, long ages, before animal life shall exist in harmony with the laws of sensibility and the dictates of perfect beneficence? Why has it not been arranged that the products of respiration shall serve for food directly and at once? In answer to such a conception, it were easy to show that it violates the law of the conservation of energy. It is to ask that an animal shall be a perpetual motion. Now, if an animal were itself an universe, or a completely individualised and insulated being or thing, so placed and constituted that all the energy which actuated it returned into itself, this were possible. But for no thing whatever, that is a member in a system, is a perpetual motion possible except as a current passing through it. In order to the maintenance, and still more the increase of life in nature, not only is the leaf necessary as well as the lung, but these two must be placed in a definite relation to one another. Neither can that relation to be of the simplest kind. It would not do merely to dissolve the leaf in the same medium as that in which the lung breathes, and leave the alimentary particles to be absorbed by the lung generally, whenever they came in contact with it. This would be merely to surround the lung with the products of respiration, and so to clog and destroy respiration. But let the leaf be dissolved in another medium than that of respiration; let it be dissolved in water, for instance, which is at the same time permeated by air fit for respiration, and then the lung (or respiring organism) existing in this water, may both breathe in virtue of the oxygen in it, and be fed in virtue of the dissolved leaf-particles in it, and that possibly by a peripheral absorption, either partial or general. In this way, then, by differentiating the medium around it, a very simple organism may lead the life of an animal. Thus may there be æther-aerial and aer-aquatic creatures of indefinite minuteness and simplicity of structure.

But may not an animal live in a single medium, as for instance in air? Yes, if its mass be large enough, so that it may be placed around the leaf, thus giving to nature a cell or stomach, with food only for contents, the medium for respiration being outside. Now a verification of these deductions is precisely what we find in nature. The mixed medium of water containing air, is everywhere teeming with most minute and simple highly animated organisms, in which no trace of mouth leading to a permanent stomach can be discovered. They both breathe and feed by their periphery in whole or in part. But of all purely dry air-breathing species is not a stomach a characteristic?

And, indeed, of any animal considered as a subject of alimentation and exhaustion, may we not say that in the most general point of view, it is a large polymorphous cell, with outer and inner walls, and adventitious matter lying within? Drawing energy from the ambient medium in which it exists, it lives and gives out to that medium aeriform particles which tend to concrete into the beautiful forms of vegetable nature. These particles again, when concreted, the same animal lays hold of and places within itself again, destroying their concretion both mechanically and chemically, and presenting them within itself to its own working organisation to be assimilated by it to itself wherever repair is wanted, —and all this for supplying the desires and demands of sensibility, the well-being of which is enjoyment—of which, however, we cannot now speak.

These things considered, it must be admitted that there is no rational ground for indulging, after being enlightened by science, in that moral recoil which the sensitive soul naturally feels at first, when contemplating the animal kingdom, and observing, as is inevitable, that so many species are maintained in life, only by putting to death so many individuals of other species. If, indeed, this economy of food were carried so far that the amount of sentient life in our planet, the number of creatures which exist and could enjoy existence were diminished by it, there would be a legitimate ground of complaint. But all the evidence goes against such a conclusion. Of those creatures which constitute the food of others, the world is as teeming as teeming can be. They have been endowed with such abundant fertility and reproductiveness, that if we are to seek out the causes of their sufferings, we shall find it in this fact, and their struggle for existence among themselves in consequence, rather than in their liability to be made the prey of other species. Meantime it is worthy of remark, that the vegetable kingdom has been laid under the same law; so that there may be as much vegetable matter as possible for vegetable feeders. Nay, all the excretions of animals when alive, and all their remains when dead, are appointed to be converted, if not immediately into animals, then into the beautiful and nutritive forms of vegetable matter. Add to this, that the species which crowns the zoological scale, and is called upon to a certain extent to preside over nature, has the power of adding immensely by cultivation to the fertility and productiveness of the soil, and therefore to the production of food for animals; and it must be granted that, so far as we can see, all that is possible in the circumstances has been done for the well-being and the abounding of animals.

Creation in its rise preludes as its offspring nothing but animated creatures, consisting of pure and undifferentiated protoplasm. But if they are to live, they must breathe, and they cannot breathe without becoming emaciated and requiring food to maintain them in well-being. Meantime there is no choice of food. The stronger must feed upon the weaker; that is, the stronger must cause the weaker to merge into them, and to be completely assimilated to them. Now, this being the primal nature of alimentation, it also appears that though such is the only food animals can have as yet, it is also the very best food possible, for the entire mass of that which is eaten is available for assimilation. There need be no rejectamenta at all. The economy is perfect.

Why, then, is an economy which seems so faultless objected to? The reason is, that the thought or spectacle of one sentient creature destroying another, even though it be under the necessity of avoiding starvation, hurts our sensibility. True, we do this ourselves every day without blaming ourselves. But that it should be an institution in nature, and that, so extensive as it plainly is, seems surprising and even shocking and disturbing to true devotion. The fact is, that in sympathy with the animal seized by another as its prey, we invest it with those feelings of anguish and misery, heightened by the horror of approaching annihilation, which we ourselves should experience were we ourselves in its place. But to all of this doubtless the unreflecting creature which is destined to become the food of the other is an entire stranger. There is also, I think, ground for inferring that a certain amount of compression, and that not difficult to effect, induces anæsthesia, so that to all that happens after the act of seizure the animal seized usually is a stranger. Besides, there is a state of wrapt attention, of which the lower animals seem to be eminently capable, during which, whatever injury may be inflicted upon the organism, no pain is felt. Of this a shocking instance was recorded in the public prints the other day. A man (or rather a brute) took a bet, that his terrier, which had just killed so many rats in so many minutes, would kill as many more in the same time, though one of its legs was chopped off. The bet was taken. The terrier's leg was chopped off, and his owner won the bet! Insects also, and even frogs, how little they seem to mind the most serious and even fatal lesions!

Let it not be asked why there should be, in sentient creatures, a liability to pain at all. Perhaps a liability to pain is implied in a capacity for enjoyment. And, at any rate, a liability to pain, when viewed as an institution in nature, is manifestly a benevolent one. It is the embodiment in the very organism itself of an argument to protect the integrity of the organism, far more influential, and far more extensively applicable, than any purely logical or intellectual consideration could be. That it should still exist and force the attention inexorably, and retain its hold of the sensibility, and, in a word, be pain, when the organism is fatally injured, and when the pain can of course be of no use as a protection to life, is merely one of those illustrations which are constantly occurring in nature (and which must be constantly occurring in every purely dynamical system) of the fact that the law must take its course. The design of the law is benevolent; and its fulfilment upon the whole is productive of happiness or protective against evil, but in particular cases it acts otherwise.

But, finally, it may be asked, why death at all? And here a most interesting inquiry presents itself in its relation with our philosophy. Nor ought it surely to be against that philosophy, that the conclusions to which it leads are eminently orthodox. Thus, the dissolution of a living organism considered as death, that is, as an evil which has befallen it, accompanied usually by pain, and certainly with the cessation of all previous enjoyments, and the possibility of all future enjoyments in the organism itself as the abode of sensibility—this, which is what is usually meant by death, does not attach to an organism, if its organisation be internally as perfect as it may normally be, and if it be placed in a perfectly harmonious relation with its environments,—provided that organism has been created in perfection at once. If Adam and Eve were called up into being of full size upon the spot, and that spot a paradise, then, for aught that appears, they would be naturally immortal. Anatomy, when it separates itself from pathology, and as a purely mechanical science, makes a study of a full grown healthy human body, can discover no cause why the organism should strike work or fall to pieces after seventy or after seven hundred years, or at any time. Our organism is not like the time-piece of the watchmaker, which from first to last consists of the same particles, which therefore eventually cannot but be exhausted, and so becomes a wreck. Organisation, as fast as any particles in an organism are worn out by work, replaces them with others, fresh from the sunbeam. And—but for a certain fact—the human frame, if fitly placed, would be a living structure as truly everduring as a river, which, by the aid of its surroundings, the mountain, the ocean, the sunbeam, runs on for ever. What that immortality-destroying fact is, in a religious point of view, we have nothing to do with here. But it belongs to us, as explaining phenomena scientifically, to state what it is that prevents immortality now. And that we find in the appointment for the first woman, that she should bring forth children. Under the cosmical law of assimilation (acting as reversion, one of it most inexorable forms), whatever has had a first childhood, must have a second childhood too. Birth and growth imply decay and death. But meanwhile by birth, and during growth, as I have elsewhere shown in detail,* the human organism has become the mother and nurse of a non-material, a purer than ætherial being, in a word, a spirit, which survives the dissolution of the organism as naturally as the material atoms themselves, of which that organism consists.

But while it thus comes out scientifically, that the immediate creation of the first man, as affirmed in Genesis, and his immortality harmonise and imply each other, we ought, if we are to apply the term death, viewing it as an evil, to the whole of creation, to limit our conceptions to the actual amount of the evil that is in it. The fact is, that with regard to the whole of animated nature, with the exception of our own species, death, inasmuch as it is the necessary preliminary to dissolution, is not an evil; for the dead need no food; and every living creature before it dies tends to give birth to more; and that state of matter which is secured by dissolution is a higher state of physical existence than that in which the same matter forms an organism. When in a state of dissolution, the constituents of living bodies are æriform, and this is a more perfect state than the concrete, or indeed any other state whatever. And hence the determination of organisms towards death and dissolution, as soon as the ancestral development insisted upon by the law of assimilation has been attained, is not an evil. If the organic elements had feeling, and were capable of desire, they might possibly wish, and ought certainly to be excused for wishing, to be off from the often questionable situations in which they are held down in an organism. Better surely a dance in the sunbeam—a dance, moreover, during which they may be constructed, according to our philosophy, into certain tissue-elements, which, in their turn, need only to be combined, in order to give being to living organisms aloft, so that the dissolution of heavy life on the earth's surface may possibly animate the air with most light and lucid creatures.

* See Part I. p. 151.

CHAPTER XI.

OF REPRODUCTION AND SEX.

It has already appeared to a certain extent, and it will be shown more fully in another chapter, that a single material element may be accepted as a prefiguration of an entire individualised organism, animal or plant. And here, after considering the functions of respiration and alimentation, we may inquire whether a single material element does not prefigure also the function of reproduction, and haply explain also the fact in nature of difference of sex.

The function of reproduction is generally regarded as the very characteristic of living nature, whether animal or plant. Many individual objects are supposed to want it, and to them is denied a place in either kingdom. But here, as so often, it falls to us to extend the limits of conception. Reproduction is not confined to what is usually regarded as an organic being, whether animal or vegetable. Reproduction, as a nisus at least, is universal. It is, in fact, the simple expression of the law of assimilation operating in time as well as in space. Thus wherever there has been individuation by integration of successive parts or particles, then, though the process may have been completed inasmuch as it has redintegrated the ancestral form, still that process must tend to go on; for never and nowhere is there any suspension of the cosmical law. It cannot now, however, bestow its operation on the further construction of that which has already attained to its fully developed form and structure. It must now, therefore, operate otherwise. And therefore it is only to be expected that it will commence the construction of other forms which shall be like the ancestral form in its first beginnings, and which shall be capable of development into that form when the conditions of existence are suitable and aliment is supplied.

Nay, the reproduction of like objects by antecedent objects must go much further than this. And so it manifestly does. Thus let there be a saturated fluid, liquid or æriform, and into it let a bit of concrete matter project or be suspended, and then as soon as the temperature falls or any condition favourable to solidification occurs, something concrete, an element of crystal or of sublimate will soon form and grow into visibility, and in due time come to possess the features proper to its kind. Again, when a vessel with smooth walls contains that which is wholly liquid—as, for instance, pure water—that liquid may be cooled far below the degree at which it usually concretes. But on dropping in a particle of a concrete, say a bit of ice, into the water, the whole immediately assimilates itself to it—the whole starts into ice. And conversely, when such concretes are overpowered by a fresh affusion of liquid, the latter assimilates them to itself; the concretes disappear in it, and the liquid is reproduced. And these phenomena, which may be observed from hour to hour in the laboratory, take place secularly in nature. Thus adjacent rocks, even where entirely different origins are assigned to them, assimilate or tend to reproduce each other on their confines, and are seen to "pass into each other."

But it is in reference to more fully individualised and more easily transformable objects that the phenomenon of reproduction, either molecular or massive, shows itself more articulately. Such is the process of healing and of ulceration. Thus, given a living concrete tissue and liquid plastic matter adjacent to it, then either the solid or the liquid, according to the intimate conditions of existence, proceeds to reproduce the other. If the concrete prevail, there is healing up. If the liquid prevail, there is ulceration or destruction of tissue. Of the same order are the phenomena of normal growth generally. Given a group of living cells and a suitable pabulum, then these cells, nothing preventing, will generate others. Nay, so general is this phenomenon, that it is most usually held to be imperative, in order to the development of more living cells, that there must be pre-existing living cells to begin with. Let us not fail to remark, however, that in order to the increase of cells an external pabulum as material is not indispensable. The law of assimilation may also, and that most economically, be fulfilled by the segmentation or spontaneous fission of the parent structure. And this, being the most economic mode of all, we see to prevail in the beginnings of very many species, from the most simple Gregarina to the human ovum, the commencement of the most highly organised being.

As to the morphological principle in the developing individual which rules the phenomena, and which along with assimilation to the parental form determines the actual form and structure of the young individual, it is the same law (of assimilation) in its cosmical function, namely, a determination towards the spherical and cellular. And this is the usual course. Under the linearly-acting-forces or currents arising from a situation on the surface of a revolving gravitating sphere, the form of the future individual, spore or ovum, which at first is to be expected (as has been shown) to be more or less spherical, becomes elongated. But assimilation, at once to the previous sphericity and to the spherical in general now reappearing, forthwith tends to partition this elongated form into two shorter or more nearly spherical parts. Then these, by the same process, are partitioned into two others, and so on; the increase thus taking place at the rate of 2, 4, 8, 16, 32, &c.; the portions or cells obtained by this process of segmentation resuming more and more the spherical form.

And here we may remark in passing, that in this way also this phenomenon is to be explained that every axial form, filament, or fibre tends to be crossed by nodes or septa and to become moniliform more or less (muscular fibre, conferva, axis of plant, &c.). These nodes or septa, &c., are a nisus at giving equators to the axial forms (branches and foliage being the more successful fulfilment) and of breaking down linear forms into frusta, which shall be as spherical or monometric as the conditions of existence will allow.

But a reproduction still more elemental than any of these attaches to our theory. Thus the nucleus of our material element consists of 32 ætherial elements confluent into one, but previously discrete. Hence, under the law of assimilation, a twofold reproduction. First, by secular partitionment and assimilation one material element will tend to reproduce its former state, and to part into 32 ætherial elements again; and, secondly, out of these 32 ætherial elements there will tend to be produced 32 material elements as from the spawn of one. For each of the 32, after being set free, must, under the law of assimilation, be possessed of a virtue which it had not before. It must continue to mirror within itself, and, as it were, dynamically remember and so to act towards the reconstruction of such an object as that of which it is itself the offspring. It must, in short, act as a spore, a bud, or an ovum. A single material element having opened up must tend to give birth subsequently to 32. And thus we find at the very origin of material nature, the preluding of that very great fecundity of organic species which has excited so much wonder, and which, in consequence of the necessity of alimentation with an inadequate supply of food, gives rise to the struggle for existence, which is the cause at once of so much suffering and of such advancement in nature. For in this struggle those individuals who are least fitted for it, and which occupy the worst positions, must succumb; while the survivors, impressing, as under the law of assimilation they must tend to do, their superior points and powers upon their descendents, must tend to be the parents of an improved progeny. If it be asked, how come they to be possessed of those superior points and powers in virtue of which they have survived, the only answer possible as yet is, that in them, along with the vigorous operation of the special type as maintained by heredity (that is, the operation of the law of assimilation in reference to time), the influence of the pangeneric type, the type of types, the tendency towards the spherical and cellular (that is, the operation of the law of assimilation in reference to space), must have been eminently strong, as also their situation among their environments, compared with that of others of their own kind, most favourable. And it is curious to remark, that this view, though so different in its conception and statement, does not differ practically from that of Mr Darwin. For the capacity or tendency to indefinite variation in all directions which he proposes, may also be described as a general tendency in organisms to radiate from their centres, which is the same thing as a nisus at the spherical and cellular.

But in order to account for the actual forms of all organic species, other morphological data than those recognised in Darwinian writings are indispensable; and it is to be regretted that that which is capable of explaining only a part should be advanced as if it could explain the whole. In order to this, along with a knowledge of the law of assimilation operating both in reference to time and space, and thus, while maintaining and reproducing hereditary types, advancing them also towards more perfect structures, a knowledge is also indispensable of the forms of the atoms of the organic elements, especially carbon, and of certain vapours, especially common vapour and ammonia, and of many planetary conditions and applications of forces at present wholly unknown, and which are likely to remain wholly unknown so long as students of physical science refuse as they do now the helping hand of theology. Nay, after these things have came to be known, it will probably be ages before the human mind can give the plan or explain the structure of the simplest and most minute of the Protozoa. The human eye, when assisted by the most powerful microscope that ever can be constructed, and by means of it seemingly made to touch the object of study, is yet at an all but infinite distance from the region where individual molecules come into view. For them there is the mind's eye alone. And in this there are at the present day not only so many motes, but so many beams, that in order to clear rational vision a distant future must be waited for.

Meantime, referring to Darwin's theory, the idea should surely exalt our conception of the Creator, that already, from the first, in the structure of the material element itself, He, having eternity at his disposal, provided, that in good time the human hand should be given to nature, and in the same species a brain so powerful and so related to the spherical, the type of form, that in its focus of action as an organism of æther with its appropriate currents and matter supporting it and them, a being of a higher order than the merely material or the purely ætherial should receive its birth and grow in energy, even a spirit, which, when the organism that served as its mother and nurse has performed the cycle of its function, and given up its matter in individual particles to fly about in the air for a season, shall continue to exist, and go to join the world of spirits, and live in the realm of light, and participate in an endless progress towards perfection and in enjoyments of the highest order.

A theory of development, whether it be the Darwinian or any other, does not deny design in nature. Rather it claims all nature as one grand design, yea, a design realised with the utmost perfection and economy, inasmuch as it assigns to those parts of nature which are first created the duty of realising the design of the following parts without needing the collateral interference of Him who is the author of all—an interference which, if it were needed, would it not imply some defect either of foresight or of power? No doubt, during the working out of such a method of creation, it is only to be expected that many individual objects shall be built up in which all the attributes of the mind of Him who designed the parts as a whole shall not appear, at least to such finite insight and thought as man possesses. The awarding existence to a dynamical system which is to act mechanically, and therefore elastically and rhythmically, and to be allowed to effloresce into all that belongs to it as such, implies that, along with the development of opposite polarities, there shall be also that of opposite endowments. And, therefore, we may expect in sentient nature also, objects and actions which, viewing them in the light of sentiment, we must regard as permitted rather than as directly willed by the Creator. Now this is precisely what we find in nature. The grand method adopted, while it gives to nature an all but infinite variety of objects, and never fails to build them in harmony with themselves and their surroundings, so that the machinery is everywhere exquisite, and the actions everywhere appropriate to the machinery, yet gives room for a sentiment which both the object and the action most immediately awake that not unfrequently conflicts with those attributes in the Creator which our intuitive convictions of what He is, as also the moral nature which he has awarded to us, peremptorily insist upon.

It is strange how little regard theologians sometimes pay to features in creation, which to some naturalists seem insuperable difficulties to the belief, that nature is the creation of a benevolent Being. A writer who is at once an officiating clergyman in Cambridge, and a professor in the University (nay, a master in mathematical and physical science, and the author of a molecular theory which is very scientifically wrought out), in a work on the Scripture doctrine of creation, when criticising the theory of evolution and repudiating it, again and again adduces the lion as a witness, that such a noble creature could not have been created in such a way! Surely the lion is *par excellence* one of those destroyers, in reference to which every considerate theist should be thankful for any derivative theory that would account for their creation otherwise than by the very finger of God directly applied to model a brain, teeth, claws, tendons, and skeleton, all so exquisitely co-ordinated with one idea, and that fitness for the one special work of seizing and destroying living creatures as good or better than the beast itself, only not so strong.

But to feel the necessity in order to the satisfaction of our moral nature of some large and all-embracing view of creation, we need not wander from our present subject. When thinking of reproduction, the fact of difference of sex presents itself. Now that this difference is not essential to life, and that it exists in material organisms alone, we are assured. And looking at it without the aid of adequate science, really nothing seems more uncalled for. Why, may it not be asked, is one-half, perhaps, of all the individuals, and that in the higher and highest species, rendered useless for the continuance of the species without the concurrence of the other half, this other half being otherwise useless altogether for this great end? What, may it not be asked, can be the reason of the institution of sex, and how can it have come into being, sex, a peculiarity of organisation extending to almost all organic beings, and which, in our own species, is the cause of so much suffering, and if of enjoyment also, yet of enjoyment so low, that all are ashamed to speak of it? It certainly looks as if to account for such a state of things, we must suppose that nature is the work of some Demiurge, or, at any rate, that there must be some or other cause than that of a Supreme Reason acting freely in the absence of all limitations.

Now, does not a reference to the structure of the material element itself, as it has been conceived in these pages, hold out a prospect of explaining this seeming imperfection in the individual? Thus we have supposed that the body of the material element consists of 32 ætherial elements confluent into one, yet bearing traces of genesis in two layers of 12 and 20 respectively. Moreover, on conceiving the genesis of that element, we supposed that the 12 were central and the 20 peripheral. Now that we did, simply because this arrangement was the easiest mode of synthesis. But morphologically considered, the structure would be more perfect, more spherical and cellular, if the 20 were central and the 12 peripheral. And for anything that appears to the contrary, this arrangement may exist as well as the other. Now, if so, if both may be, then both will tend to exist in equal numbers; for as soon as one of one kind has been constructed, the law of differentiation (induction) will tend to secure the construction of one of the other kind as its neighbour. Here, then, is at once an encouragement to inquire whether this difference at the very root of material nature may not prelude and necessitate a difference of sex in composite organisms; for nothing is more remarkable, where sex is most fully pronounced, than the equality of the numbers of both sexes.

But of more consequence to the investigation it is, to inquire whether the difference between the two kinds of material element has any analogy to that between the two sexes in the same species. Now, as to this, it may be remarked, that though the law of assimilation will doubtless impose the same ætherial volume overhead upon both, yet the body (or nucleus) of that in which 20 are central, will tend to be somewhat larger than those in which 12 are central. In this, then, we see an accordance with another phenomenon of sex, for one of the sexes in the same species is generally somewhat larger than the other.

Further, when compared with everything else, the two sets of material elements may be said to be similar to each other. But when compared with each other, they may be said to be dissimilar as well as similar. Now hence, in virtue of their dissimilarity, they will tend to unite together; and in virtue of their similarity, they will tend to remain separate like similars in general. And these twofold tendencies will be satisfied if, as a consequence of the act of union, the amount of difference between them be diminished; for in that case, after union they will separate, and thus will remain separate until the previous amount of difference accumulate again. As to the mode of action in both, arising from difference between them, it must tell outwardly by a difference in the times of the excursions and retreats of the ætherial elements in their atmospheres or dynamispheres. In the one, the excursion of 12 must be simiItaneous with the retreat of 12 in the other, and that of 20 with 20, and consequently 12 must be ever encountering 20 in the same phase of excursion or withdrawal. Along with a perfect receptivity on both sides, there must therefore be also a certain conflict. And this conflict must, during the time of union, tend to confuse the reciprocal rhythm altogether, and indeed to render the same rhythm radiant in both, and so to bring the union to an end, and to effect separation; on the occurrence of which the previous normal action (preluding respiration) will gradually be re-established. It must be remarked, however, that the state of the two, after this sympathetic and yet conflicting state of union, will not be quite the same as it was before. Assimilation at least as to an aura must, to a certain extent, have taken place between them. A loss, at least as to its previous power of functioning, must have been sustained on the side of that whose parts most engaged are represented by the number 20, and a corresponding gain must have been made on the side of that whose parts engaged are represented by the number 12. Supposing, then, that we now are in the midst of speculations which relate to sexual union and its consequences, it follows that of the two sorts of material elements which are otherwise identical, but differ as to the order of the supraposition of the two layers of ætherial elements which constitute their body, that in which 12 are central—that is, the kind most easily constructed—preludes the female sex, while that in which 20 are central preludes the male. Now is there not here again, one of those somewhat obscure verifications which, nevertheless, are all that we can reasonably expect, while yet we are at such a distance from the visible reality? Is it not generally agreed that the female in general is more easily constructed than the male, and that the as yet unimpregnated ovum or ovule is a simple thing compared with the spermatozoon or antherozoon?

Moreover, it is not without great interest to observe, also, that this theory of the genesis of sex, implies that originally every simply individualised organism tends to be bisexual or hermaphrodite, containing in its own organism both male and female parts; but yet bisexual on such conditions that, in order to the continuation of the species by a succession of individuals, reciprocal union and impregnation is required. Now, that such is the tendency of actual nature, embryology and natural history go to prove more and more every day, although discoveries in this line, seeming as they do to imply the superfluous and therefore the unexpected, are but slowly made.

And here a question with regard to cell life suggests itself. Are not the nucleus and the nucleolus in some respects in the relation to one another of the different sexes?

But enough, it will be said,—long ago enough—of such transcendental imaginary biology. And, indeed, I might not have ventured so far, if I had it not to remember how, when I was young, I was the object of ridicule at the University for accepting doctrines in "transcendental anatomy," newly imported from the Continent, which are now the common belief of everybody. Besides, the enjoyment that attaches to what promises to be new insight into the mysteries of nature, is so great and so high, that he who has experienced this kind of enjoyment in any good measure is emancipated equally from the love of applause and the fear of ridicule. The social principle in our nature is, no doubt, sometimes very inexorable. Man is emphatically made for loving and being loved, and therefore honoured by others of his own kind. But where these conditions of social enjoyment are denied, he may have a grand revenge, by devoting himself wholly to the pursuit of truth.

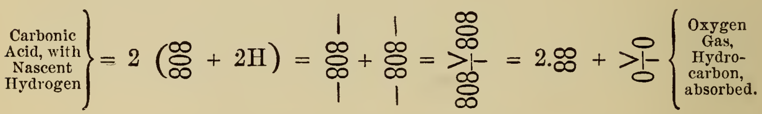
CHAPTER XII.

VEGETABLE MORPHOLOGY—ITS GENERAL PRINCIPLES.

With the light which we now possess as to the possible origin of difference of sex in organisms, we are in a condition to venture on an explanation of the forms and structures of plants and animals in some of their more minute details. And here it will be remarked, that our theory would lead us to treat first of animals and not of plants, as also of such as are most minute and microscopic, rather than of those which are palpable and large. But it is so difficult to be sure about that which is invisible except by the aid of the microscope, and the animal cell is so rapidly changeful, that scientific prudence dictates our taking in hand first, not the animal cell in the animal, but that cell, when rendered more stable by being encrusted or encased in cellulose, that is, the vegetable cell; not indeed when single or as a microscopic object, but when aggregated and constituting a plant of the more perfect or typical kind, say a flowering plant.

Now here we may remark, in the first place, that in order to be able to analyse and come to understand the form and structure of the typical plant, and of the vegetable kingdom generally, its relation to the animal kingdom must be remembered. That relation, in its most eminent feature, is to supply the latter with food. For although the animal may have a form which exposes as small a surface as possible to the ambient medium—that is, may be as compact and spherical as is compatible with a locomotive apparatus, &c.—yet inasmuch as an animal is essentially a breathing creature, it cannot but be continually losing of its substance, and imparting that loss to the ambient medium. And hence the place in nature for the plant. It is wanted to gather up the products of respiration which are diffused in the atmosphere, and to present what in them has been lost by the animal for the redintegration of the organism again of the latter. The plant, therefore, may be expected to have a form which is expanded as far and wide in the ambient air as that of the animal is centralised. Now this is clearly the character which the vegetable kingdom displays. Its characteristic is organism expanded into thin laminæ named leaves—laminæ which possess the power universally, during the period of day and sunlight, of absorbing the products of respiration and of decomposing the carbonic acid, appropriating its carbon and letting the oxygen gas go free; thus providing for the animal kingdom aliment both ways: (1.) Aliment for redintegrating the animal tissues; and (2.) Aliment for sustaining respiration!

What the apparatus in the leaf, by which this decomposition of carbonic acid is effected, the popular chemistry has as yet made no step towards discovery. It is only known that in the laboratory such decomposition is impossible by any process which could be supposed to take place in organic nature. I have elsewhere shown that it arises, in all probability, from the construction in the vegetable tissue of tetratoms of hydrogen, which, being highly negative in form, are similar to oxygen in their mode of action, and are therefore repulsive of the oxygen which exists in carbonic acid, and so decompose it. The process may be imagined to be something of this sort. In the sunny leaf, where essential oils, &c., are being developed, let there be atoms of nascent hydrogen. And let one atom attach itself to each pole of the atom of dioxide of carbon as if to reduce all to common vapour and glance-coal at once, then instead of this, and for its indefinite postponement, we may have the equations—



Possibly in some such way may carbonic acid be decomposed by the power of the living foliage when aided by the incidence of the sunbeam or the light of day. But meantime we must content ourselves simply with regarding this admirable power as residing in chlorophyll, a substance in vegetable nature which is so named because to it the general verdure of the vegetable kingdom is owing.

The expanded lamina or leaf, then, is the characteristic element of vegetable nature. But in being led to this conclusion, have we to give up the spherical superficies which we have maintained, that the law of assimilation gives as the culminative form of every object which is individualised by nature—a form seldom fully constructed indeed, but always aimed at? No; the vegetable lamina or leaf, or rather the umbrella of leaves which is the fully developed form of the leaf-bud (that bud as spherical as its mode of nutrition, &c., will allow), is also as spherical as these same conditions will allow. And if each single leaf in the phyllotaxy of the bud-system, while extending in a radiant manner to the utmost acquires an elliptical, oblong, or very lengthened form, as it so often does, still the tendency to be circular shows itself. It generally subdivides the leaf into leaflets or parts, each of which, though developed under the assimilative influence of the whole leaf, is more circular than the whole.

And while the circular, as modified by its unavoidable mode of nutrition and pressure in the bud, appears in the individual leaf, and still more in the system of leaves, which is the development of the bud, the spherical appears in the distribution of the whole system of leaves proper to the entire tree, shrub, or plant, if it be fully borne up in the atmosphere by trunk or stem; the hemispherical, if it be not. On this subject I saw my way (as it seems to me) so long ago that on July 12, 1860, I read a paper before the Botanical Society of Edinburgh, entitled "Vegetable Morphology, its General Principles," which was, I believe, published in the Transactions of that Society, and also in the *Edinburgh New Philosophical Journal* for October of that year, in which the view I am now advocating was set forth. An extract from that paper will serve my purpose now, while no one need regret the repetition, since the periodicals in which it has already appeared have, I presume, gone into the vault of all the Capulets :—

"The forms of plants in general, the plant-form, why is it what we find it to be, and not otherwise?—that is a question which science has not yet answered. Philosophical botanists have indeed shown that all the more perfect plants may be regarded as consisting of an axis with its appendages; and that all these appendages, however varied in their forms and functions, are either leaves or transformations of leaves. They have also shown that all the special organs of plants have their uses, uses often manifold, and always good, and that the whole vegetable kingdom is beautiful, and calls upon every beholder that possesses sensibility to adore the Creator. But it has not yet been shown why the forms and organs of plants are what they are, and not otherwise; why the typical plant consists of an axis tending to spread out and radiate upwards and downwards into branches and root, the former tipped by the foliage and fruit, the latter by the rootlets and spongioles; why plants consist of the matter of which they do consist, and not other matter; and why they are so highly coloured and so fragrant. For all these features of the vegetable kingdom, and others of the same order, it has hitherto been possible to assign, not physical and physiological, but theological and moral reasons only. It has been possible to refer them only to the will of the Creator that they should be as we find them. Now, this is no doubt the ultimate reason; and for moral purposes, and for men in general, it ought to be sufficient. But to the man of science it is simply equivalent to saying, 'God knows;' for the man of science is not at liberty to forget that whilst the Creator is the absolute Will, He is also the Supreme Reason, and as such has implanted in the soul of man the instinct of Philosophy, whose calling is to lay hold of Nature and wrestle with her for light as to the reasons of things, and whose word to Nature ever is, "I will not let thee go except thou bless me.'

"Doubtless there is a sufficient reason why the plant-form is as it is and not otherwise; and it is for the philosophical botanist to discover if he can what that reason is. To this inquiry there is in fact a moral and a theological, as well as a purely intellectual stimulus. Thus the forms of plants, at first sight at least, seem to exist in violation of all wisdom; they seem to be the very counterpart of those forms which pure intelligence, contemplating excellence of form as such, points to as the best—the very counterpart of those which geometry and dynamics sanction. Thus, though they be so useful and so beautiful, they are of all things the most fragile and fading; they are the sport of every blast. Other beautiful products of nature, gems, for instance, or pearls, may be set in gold, and stored up or worn by many wearers without being worn out. They preserve all their charms for many generations. But the most beautiful flower, the most fragrant nosegay, is faded before the evening be over. Now, why is this? Constant observation of the fact may indeed have so familiarised us with it that we may never think of inquiring, or even deem it needless or strange to ask. But there can be no doubt that if, in perfect ignorance on our part of the fate of flowers, a lily or a rose were presented to us, we could not in the first instance feel grateful enough to him who had given us such an exquisite production of highest art, yet, as soon as we saw how it was going with it, our gratitude would soon give place to a still stronger indignation, that he had merely mocked us with the possession of a thing so fading as to seem worse than the want of it. Now, why is it so? Why is the plant-form so fleeting? I answer, because it could not be more solid or more lasting than it is, if the vegetable kingdom is to take its place in nature, and to fulfil its mission there—that is, to intercede between and unite in harmony the fickle fleeting air and the fixed earth. Plants do not exist in disregard of the laws of a pure morphology—that abstract doctrine of form and structure which geometry and mechanics teach, and which the forms of the heavenly bodies, and of all stable structures exemplify. Plants realise those very forms which are most stable and cosmical up to the full measure that is compatible with their place and calling in nature, and the end they are appointed to serve.

"But here it may perhaps be thought that all this is no more than an affectation of mystery, a raising of difficulties where none exist. That the forms of plants should be fragile, it may be justly said, so far from being a fault in their construction, is the very circumstance on which their usefulness depends; for, to the very extent that they are easily destructible, they are suitable as food for animals, a class of beings higher in the scale than plants, beings possessed of sensibility, beings such that a state of physical well-being in them is a state of enjoyment to them, and so teeming in multitude, and so worthy of existence, that for their sakes it may be said, in a high sense, that next to the glory of the Creator, creation exists, yet beings such that they are all in want of food, which ultimately the vegetable kingdom alone can supply, and which it does supply well in the very degree that it is fragile and easily destroyed.

"Now, against all this I have nothing to advance. I desire rather to appreciate it to the full. But I maintain that we have not reached all the reasons, or even the primary reason, why an object is as it is in all its details, and not otherwise, when we have discovered its economic use whether to ourselves or to other animated beings which are denizens of the world along with us. Such interpretations are good so far as they go; but the vastness of nature, and the multitude of its relations, demand a larger view. Thus, as to the point in hand, if we regard the vegetable kingdom as fashioned solely so as to form the best food for animals, we are thrown aback and silenced as soon as we are called upon to turn round and mark the abundance of uneatable and poisonous plants in nature. We are obliged to confess that our explanation is good only so far, but not adequate to account for the whole The truth is, that we must keep constantly in mind that creation is a manifestation of other attributes of God as well as His goodness, and specially of His unity and immutability—in one word, His perfection. Hence in nature a prevading unity of structure, and an universal harmony or homology of form; and hence, on the part of the student of nature, the indispensable necessity of a doctrine of general homology, as well as of special utility. With regard to the forms of the vegetable kingdom, for instance, besides their relation to animals as food, they exist in many other relations. . . . . The wonderful, the beautiful fact is, the number of ends, each great in its own sphere, which are obtained, nay, as it were, spontaneously fall out through the fulfilment of a single law, when the position of that law is supreme. It is the same in the moral world; but that by the way.

"What I desire now to affirm is, that in reference to the vegetable kingdom, as in reference to every realm in nature, there is a supreme law; and that in so far as it is purely determinative of form, it is purely morphological, purely mathematical and dynamical. The proprieties of form and structure, viewed in the light of pure intelligence contemplating a system, an unity, expanded or to be expanded in space and time, are never, either here or elsewhere, violated for the convenience of the individual. Universal order is never sacrificed to private advantage. Euclid of old, when he was inquiring into the first lines and properties of form, and composing his immortal work in the light of abstract intelligence, and so that it should culminate and close in the discussion of the five regular polyhedrons, was paving the way, the only way, for the right understanding of nature. And, alas ! after more than two decades of centuries, we have now to take up the subject very much where Euclid left it.

"The supreme law to which I now refer is this, that every individualised form in nature shall tend towards that which intelligence gives as the most perfect of forms, and shall attain to that form so far as is compatible with the nature and environments of the form-possessing object, as being also something else and something more than merely a form.

"But what is that form which intelligence declares to be the most perfect as form, and in which I maintain that the first lines, the most general features of a truly scientific morphology are to be sought and found? To this I answer, that were it not that demonstration is needless, because it has been demonstrated so often before, it might be demonstrated here, that that form is the sphere.

"But it is here to be remarked, that of spheres considered as realised in matter, two kinds are possible. There is *first* the solid sphere, or sphere commonly so called; and there is *secondly* the hollow sphere, or spherical superficies, or sphere properly so called. . . . . .

"Now I maintain that these two are the forms which it is the primary office of the physical forces to develop, so far as circumstances do not forbid their development. The proof of this I cannot enter upon here in detail; but this may be here remarked with regard to these forces, that however manifold their names, they are all of the nature of attraction or repulsion. Now attraction, as has been demonstrated since the days of Newton, and might have been inferred from the first morning that a dewdrop was observed, has for its first function to fashion all individualised portions of matter into solid spheres. Repulsion, again, has no less obviously for its first function to expand these solid into hollow spheres; so that between the two they constitute a complete apparatus for the development of these most perfect, most generalised forms, and for rendering them the forms of universal culmination. Nor is this all: if attraction and repulsion be not co-ordinate in extent and orce,—if attraction be appointed to rule on the great scale and at first, and repulsion on the small scale and at last—then these two forces not only give a contour to natural objects, they give also a course to nature. They prescribe as a rule, that an object shall be first constructed as a solid sphere; and that then, after being as such the representative of the prevalence of attraction, its particles shall tend to expand, and its form to develop, so as to distribute themselves in a spherical superficies, the object thus becoming the representative of the prevalence of repulsive power, or heat.

"Now, in these facts and inferences an account of the first lines of vegetable form and life is to be found.

"In keeping with what has been said of the solid sphere (that it is the fittest shape for a deposit or store of such matter as it consists of), it is seen to be the choice of Nature for the form of the vegetable being when deposited anew in the soil, when on its travels from one locality to another, when housed in winter quarters, and, generally, when the aim of Nature is to store up as much living matter as possible, so that it shall displace least of the surrounding matter and expose itself least to external injury. So far as the mode of nutrition and the type of the species permit, and as often as there is unity in the organ, the solid sphere is the culminating form of fruits, seeds, spores,* tubers, buds, &c. Nor is this all the verification which our theory derives from the phenomena. In accordance with its doctrine (that the course of subsequent action consists in the expansion of the material constituting the solid sphere into a hollow sphere, so far as the conditions of existence permit), the germination and evolution, the growth of the plant is but the protrusion and development of the contents of such solid spheres or spherules as have been named, with assimilation of surrounding matter. That the reproductive forms of plants are more dense than their other living forms generally, is matter of common observation. Vegetable matter in general floats, but seeds sink, and in fact their value is usually estimated by their density. They have invariably contents which they tend to protrude.

"Moreover, the limit of form towards which growth tends is nothing else but the hollow sphere. In consequence of the extreme difficulty of constructing this form, it is indeed, when not of microscopic minuteness, usually reached only piecemeal, only in morsels, only by the unfolding of small disks (leaves) supported on radii (axes, branches, petioles), to which the peltate leaf or system of leaves terminating the branchlet or petiole is normal, as the spherical surface always is to its radii. Many, indeed, are the obstructions to the development of a spherical contour, many the impediments in the way: as, for instance, the structure of the embryo, and the specific development proper to it; the supply of food, not equally all around but in certain directions, and

* This would be the place for an allusion to the pollen also, were it not that this product of vegetable nature requires a separate consideration.

sometimes in one only; the embarrassment of the individual plant-form in its relations with other plants, with the ground in which it grows, the weather, &c. Still, with all these limitations, it is remarkable to what an extent the spherical is actually attained in the contour of fully developed outstanding plants and trees, as also the hemispherical in those which grow in tufts or clumps. The primary axis which carries up the first foliage into the air, does indeed often keep the lead which it takes at first, thus giving as the geometrical form which circumscribes the tree, not the exact sphere, but a spheroid (the form which is nearest to the sphere), the longer axis perpendicular to the horizon. Let but the eye, when wandering freely over Nature where her forms have not been modified by the artistic but mutilating hand of man, only mark the general contour of plant and tree, and construct in imagination the geometrical form by which the plant form in the eye will be best circumscribed, you will wonder how often the circle in profile, the sphere in full form, is called for; and if not just these forms exactly, then those which constitute the least departures from them,—the ellipse, the spheroid or ovoid, the semi-ellipse or flattered tuft or clump or cone.

"This, the first law of vegetable morphology, or rather of morphology in general, as illustrated by the vegetable kingdom, enables us also to explain in a satisfactory manner a phenomenon observed in simple plants or plants with a single axis, which in itself has been considered as strange, and seeming even to interfere with specific identity of form. Thus it is generally to be remarked of simple plants, and the fact is always introduced into drawings of ideal types of plants, such as those which are figured in the popular works of Schleiden and Unger, that their lower and upper leaves, whether viewed in reference to their disks or their petioles, are very imperfectly developed compared with those about the middle axis. The upper and lowest, in fact, are often quite simple, and want petioles altogether, though those in the middle between them are finely divided and fully petiolated. Now, what is this production of leaf-stalk and foliage about the middle of the stem but a normal development of radial and peripheral matter, bent on reaching and covering as far as possible the equatorial region of the plant-sphere periphery, a region which, being at once the largest and farthest from the axis, is most difficult to reach and to fill up? The phenomenon is usually explained by a reference to the condition of the vital action of the plant at different seasons,—its feebleness towards the beginning and the end of life, when the first and the last leaves are protruded. And no doubt the life of the plant is always co-ordinated with the work which it has to do. But why is life feeble at first, or why are the lower leaves developed when life is feeble, and why the same with regard to the last leaves, when the plant is touching on its full development? Why but because that life, that energy, has a certain design, a certain law to fulfil; whereof the hollow sphere is the most general and the most perfect expression among all possible forms. The very same thing is in fact observed among forest trees and perennial plants, to which this doctrine of feebleness at first and exhaustion at last does not apply.

"But in what has preceded, I have taken for granted the existence of radii as well as a spherical superficies, of an axis as well as the foliage appended to it, of stem, branches, and petioles as well as leaves—of a scaffolding, in short, for supporting foliage widely extended in space, though belonging to a single individual, and though aiming at the formation of a single spherical shell of verdure. Now these radii, stems, branches, petioles, the law of sphericity can scarcely be held competent to supply. Were there no other law but that of the sphere which was determinative of the forms of vegetable nature, plants would be all parenchymatous and laminar, all leaf, frond, or thallus; the plant-form either successful in attaining the spherical form (as plant matter may, when individuality contents itself with minuteness), as cell or vesicle (*Sphæria*, *Sphærococcus*, *Hydrogastrum*, &c.), or unsuccessful, as is always the case where the plant is large, the *nisus* merely being indicated by the turning up or down of the edge of the frond, or the formation of a disk-like thallus, which is the first form of so many species,—now becoming a cylinder or tubular body (that is, a hollow sphere whose axis is indefinite), now a lamina turning round upwards and cup-like (*Cenomyce*, *Nidulariaceæ*), or pitted with lacunæ (*Sticta*), or turning downwards, or waved, or crisped at the edge, or over all the frond, as in many Algæ, Fungi, and Lichens. Now all this argues the influence of the sphere, and its power of direct self-construction without the aid of radii. And indeed to a much greater extent than in reference to the entire plant, the doctrine of the sphere accounts for the forms of the most fully developed and perfected parts of the thallophytes generally—those parts, namely, in which individuality has established itself most fully, and in which, consequently, the reproductive spherules or spores are produced. There is scarcely any of these tribes of plants whose forms do not culminate in spherical, hemispherical, or circular balls, shields, disks, or sporocarps of some such form, displaying lineaments of the sphere or its elements.

"But it is equally certain that, from the simplest species up to the most perfect, the plant-form shows a disposition to ramify and to distribute itself as far and wide as possible in the medium in which it grows. In the very simplest organisms (*Confervaceæ*, *Hypnomyces*), ramification, radiation, is already carried very far. And although there has been a reluctance on the part of systematic botanists to recognise any analogy between this filamentation of these simple plant-forms and the branching of more perfect plants, yet, morphologically viewed, they are obviously and certainly analogous. Nay, among these simple plants, too, not only have we ramifications, but the rami or filaments even generally succeed in expanding at their tips either into laminæ exhibiting the forms of leaves (*Delesseria*) or into float-vesicles, which are hollow spheres or spheroids (*Sargassum*), or into multiple branchlets (*Polysiphonia*), or into spore-producing cells, as is general. On comparing the branching of a forest-tree between the eye and the horizon in a winter day, when the foliage does not intercept the sight, with that of a finely branched confervöid in water, in a glass vessel held up to the light, nothing can be more analogous than the two. They must be due to the same morphological law. Nay more, shocking as the assertion may at first sight appear, there is nothing for us but to affirm that the vital nodes in the stems of perfect plants, and the septa in the filaments of the simplest vegetations, are analogous, and do in point of fact owe their existence in both (as do also the analogous productions in veins, lymphatics, intestines, &c.) to the same morphological cause—and that the doctrine of the sphere, the tendency of every axis to become at once hollow and finite, so as to approximate the hollow sphere as nearly in form as it may, thus giving ends to itself and closing up in the line of the axis step by step as it lengthens, while as yet its length has exceeded as little as possible that of its diameter. But these things by the way at present. It is the very existence of an axis and branches, often long, tortuous, climbing, that we have now to explain; for this, which is nevertheless the characteristic feature of the vegetable kingdom, the law of sphericity does not explain. We might indeed affirm cogently in general, that the sphere gives its own radii, and therefore that the law which gives the foliage gives also the axis. But in actual nature the axis takes such a lead, ascends, spreads, creeps, at such a rate, that it is manifestly the illustration of some other law. Far from aiming at a minimum of space for the plant to grow in, the stem and branches seem to delight in extending and even often straggling farther and farther."

The reason of this the article from which the above is taken proceeds to state; but not so well as another article, published in July of the same year, in *The Journal of Agriculture*, Edinburgh, "On the Parts which the Atmosphere and the Soil respectively play in the Development of Vegetation and the true Theory of Agriculture." To that I have recourse for what follows, returning to the former only at the close:—

"Of all the objects which nature presents to us, the vegetable kingdom contains the greatest beauties; and, of all the arts, the cultivation of plants is undoubtedly the most ancient, the most generally practised, and the most important. It is to plants, in fact, that we owe, either directly or indirectly, all the food by which our life is sustained from day to day; and the number of families which it is possible to introduce into our world depends altogether upon the extent to which plants may be grown upon its surface. An all-wise Providence has not, indeed, intrusted the existence of the human family to the practice of any one art. By fishing, hunting, and pasturing—by merely gathering the roots, the seeds, and the fruits which the earth spontaneously produces, a stock of men is preserved all independently of the art of cultivation. But the increase of this stock and the progress of civilisation—the numerical, the intellectual, the moral, and the religious cultivation of man—mainly depend upon the cultivation of plants.

"Yet so far behind is our knowledge in this respect, that even at the present day we are in the midst of a keen controversy as to the very first principles of agriculture. Thus, on the one hand, it is maintained that almost everything depends on the atmosphere and the mineral constituents of the soil, and consequently (since the air can scarcely be operated upon by the cultivator) that the grand secret of successful farming consists in keeping in the soil, in a state suitable for absorption by the growing crop, an adequate supply of the mineral constituents proper to that crop, as these may be discovered from its ashes. And this may be regarded as the new light, which is due chiefly to the genius of Liebig. But, on the other hand, it is also maintained that neither the air nor the ashes of plants need to be much considered by the agriculturist, but only proper tillage and the supplying of the soil with well-rotted manure, the belief being that it is upon decaying organic matter in the soil that the crop mainly feeds. And this is the view which has prescription in its favour, and is most popular with practical men.

"Now, though these theories do not conflict in practice so much as might at first sight be supposed from their statement, yet they do conflict; and a final settlement of their respective claims, if it be possible, would certainly be not a little acceptable at once to the man of science and the cultivator.

"I think that such a settlement is possible, and I proceed to attempt it.

"But, in order to do this, the reader must consent to a preliminary question—he must consent, in fact, to the inquiry, *What is the place of the vegetable kingdom in the economy of nature?* That such an enlarged view of plants is necessary when our aim is to understand them fully, and especially when we wish to ascertain the best food for them, and how to apply it to the greatest advantage, follows from the very nature of the case; for food is always a part of surrounding nature, and a demand for food on the part of the plant is an appeal to surrounding nature; and that such an appeal may be successfully seconded by us, it is plain that nature, in her contact and dealings with the plant, should be well understood by us, and her aid invoked in accordance with her own laws and in her own language. Now, though much has been done, and beautiful discoveries have been made in eliciting the relation which exists between the vegetable and animal kingdoms,* yet the same success has not accompanied such inquiries as have been made into the relation between the vegetable kingdom and the inorganic world. It has been too much the custom of scientific botanists to look at plants as individual objects irrespective of their place in nature—nay, to pluck them up expressly for the purpose of study, and to preserve them at home between folds of paper. Now, from such a mode of procedure great progress has no doubt been made in the classifying and naming of plants, but scarcely any light at all has been thrown as yet on the general features of plants, such as the cause and meaning of their forms, of their inner structure, of their composition, of their colours, of their fragrance, and but little for certain on the true economy of their cultivation. . . . .

"For the discovery of the *rationale* of the vegetable kingdom, the plant must be viewed *in situ* as a part of nature—as a development in the place where it grows by natural law of a living ember given by the Creator, and designated a seed. Nor let the reader recoil from such a point of view, as if he were going to be remitted to his studies, and required to acquaint himself with all the details of natural philosophy, chemistry, and physiology, before he can understand what a plant is, and how it is to be cultivated. No more is demanded than a general knowledge of the chemistry of the atmosphere, such as is now possessed by every inquiring person, and a comprehensive acquaintance with a single law.

"And what is this single, this all-sufficient law? Let us lose no time in setting it forth. By natural philosophers it has been most generally named *the law of continuity*, that law which forbids abrupt transitions from one thing to another, and secures their passing into each other on their mutual confines more or less. By physicists and chemists it has been seized in various manifestations, and has been named now the law *of diffusion*, now the law *of osmose*, now *of capillarity*, now *of catalysis*, now *of affinity*. By physiologists it has been emphatically recognised, and under the name of *the law of assimilation* it has been insisted upon in one of its most important operations. By philosophers generally it

* See *The Chemical and Physiological Balance of Organic Nature*. By MM. DUMAS and BOUSSINGAULT. An Essay. 12mo. Baillière: London, 1844.

has been referred to as a certain all-embracing harmony of things—a certain strongly but darkly conceived *law of harmony.* Each student of nature has observed it to rule in his own department, and thus has naturally named it in reference to that department; but in consequence of that unhappy isolation from each other in which the various branches of science at present exist, no one has observed that these variously-named laws are in reality but various manifestations of one and the same law; no one has unfolded it in all its comprehensiveness. But this is necessary to our understanding of the vegetable kingdom, its place in nature, and how to aggrandise it; and this, therefore, though very shortly, we must attempt here.

"This law is to the effect that every individualised object, once statically constructed, tends (first) to remain true to its own type, and to hand down and perpetuate that type in every successive moment of its existence as an individual or a species, the conservative action which tends to this end extending also as far as the agency of that individual or species extends, whence (secondly) each permanent object in nature, each molecule, crystal, plant, animal, must also tend to impress its own type upon all others that lie within the sphere of its influence, to assimilate them to itself; and thus (thirdly) each must tend to bring all into keeping or generic relationship, and therefore to promote an universal harmony. Whether objects in general, or more than a few, shall succeed in thus affecting each other either deeply, or in any such degree as may be marked by the senses of an individual observer in the course of his life, or of such history of the past as we now possess, is a question of detail. It is the tendency only at once to permanency of the specific type in the individual, and to the assimilation of all to each and of each to all, and to its actual environments and conditions of existence, that our law affirms and provides for. And that such a tendency does indeed operate universally all nature proclaims aloud, inasmuch as all nature is seen to be a harmonious whole. Every object, while tending to continue true to its present self, and to echo and repeat its past in its future, tends also to mirror itself in the kindred objects around it, or to vibrate in harmony with them. A bright body illuminates the dark, a hot body warms the cold bodies around it. A polarised body polarises such as are susceptible of this mode of existence. Molecules of an eminently undecomposable nature, when introduced among others which are tending to decomposition, arrest that process. Salt preserves meat. And molecules which are themselves undergoing decomposition, when introduced among unstable molecules, assist them in decomposing. Yeast causes fermentation. Conduction, radiation, polarity-induction, catalysis, antiseptics, ferments, &c. &c., are all so many manifestations of one and the same law, which in all tends to the same issue, viz., to assimilate to individual objects, or to that which is fixed in them as primary data, all the others around, so far as they are assimilable or contain assimilable parts, and thus to secure a general sisterhood and harmony among all. I have lately shown* that inertia, elasticity, gravitation, polarity, and other agencies, may all be referred to this law, and are in reality merely uniform phenomena in matter resulting from its paramount operation.

"But for our present purpose it will be best to illustrate it in reference to *Assimilation*, as that process is manifested in the life both of plants and animals, and as it is understood in physiology. It is quite a typical illustration of our law, and as it is that by which all growth and life are maintained in organic beings, it is of supreme importance. Now, assimilation is simply to the effect that when two dissimilar yet kindred media meet together, the one consisting of plastic material, and the other of a living organism in want of redintegration or increment, that organism, while maintaining it own type, assimilates more or less the plastic material to itself and organises it; while the plastic material, on its part, assimilates more or less the organism to itself—a circumstance which, though not remarked in physiological works, is altogether needful to be kept in mind in order to a full and satisfactory conception of the phenomenon. Thus, if the plastic matter consist of cell-material in the liquid state, and the living organism be a single living cell, or a mass, or, as we may say, a battery of living cells, constituting an organism which has suffered lesion, or is not yet full grown, then the plastic liquid in contact with the cellular concrete becomes itself cellular and concrete; new cells are developed in it; the organism grows. But the assimilative power is not all on the side of the concrete part. In the region of mutual contact and action, the cellular surface feels the presence of the plastic liquid. It is more than wetted by that liquid (though the phenomenon of wetting is a superficial assimilation)—it is rendered plastic. The new cells are not added abruptly outside the old. Along with the formation of new cells there is a solution or absorption of old ones. The new and the old are beautifully wedded together; they grow and co-exist in harmony, in unity, so long as healthy development is the order of the day. Let it be otherwise, and not a case of health; let the concrete organism in the region of the plastic liquid lose its energy, or the plastic liquid gain more energy than is proper to it in health, and then the cellular surface, instead of growing or being redintegrated, will be dissolved away or absorbed into the liquid; instead of strength there will be weakness, instead of granulation and closing, there will be abscess and ulceration.

* See *Proceed. Roy. Soc.*, Edin., Sess. 1858–59, p. 146; *Proceed. Phil. Soc.*, Glasgow, 1859, p. 52; *Report Brit. Assoc.* at Aberdeen, 1859; and as a separate work, *First Lines of Science Simplified*, &c. Sutherland & Knox: Edinburgh, 1860.

Disease is not the mere absence of health. It has positive power to extend and perpetuate itself, in so far as it is not in its own nature essentially temporary and transient. Disease cannot be met and resisted too soon, while as yet the healthy action of the system is but a little impaired by it. Hence the cause of so many deaths under acute disease; the physician is not sent for till it is too late. He is no longer master of his situation.

"But that by the way at present. What I have now to insist upon is this, that the instance of assimilative action which has now been given is but an illustration of a law which is absolutely universal; which, though not always obvious to the senses, either in its working or its results, yet is never wholly at rest, and holds good in reference to inorganic as well as organic nature. What but a phenomenon perfectly parallel, and to be referred to the same law, is the growth of a crystal, for instance, in a fluid medium, whether liquid or aeriform, when that fluid is losing energy as such, either through loss of quantity (evaporating), or of heat (cooling), while yet the number of concrete particles in it remains the same, so that, considered as plastic material for the increment of a morsel of a crystal or concrete substance of some kind immersed in it, or placed in contact with it, that fluid's condition is improving? And what but a phenomenon of the very same order with crystallisation is its counterpart, solution—that is, the reduction to a fluid form of any soluble or volatile substance in a fluid, whether liquid or aeriform, in which that concrete is immersed? In the former case the solid assimilates the liquid to itself; in the latter case the fluid assimilates the solid. In like manner, when a granular or crystalline nucleus or bed exists in, or is conterminous with, a mechanical rock, and the granular structure is seen to be extending from that nucleus or bed, what is this but an illustration among geological phenomena of the same law, the law of assimilation? Nor is it less an illustration when crystals imbedded in a rotten rock are found to be rotten themselves. Again, when two dissimilar gases or liquids are placed in contact, either immediately or with a permeable diaphragm between, and the particles of the one pass in among those of the other, as they are known to do, until they are completely diffused, and the mixture of the gases is complete, what is this but a case of assimilation, where the success, mechanically considered, is complete? Diffusion, osmose, capillarity, are but efforts towards assimilation. Catalysis is but the affirmation of the power of one molecule to act assimilatively on another. And what else is chemical affinity but the determination of molecules, when of essentially different types, and not immediately assimilable, to merge their differences by rushing into each other's embrace, and constituting a new chemical species? It is quite marvellous what order and simplicity present themselves in nature when we try to take as large a view of her processes as nature does herself, when we try to forget all laws which are merely empirical and have no reason in them, and to dismiss all fondlings and foundlings of our own. There is in nature, indeed, an all but infinite variety—a variety which appears in laws and ends as well as in forms and structures; but there is also an all-pervading unity; and the law of assimilation in its twofold function of at once perpetuating individualities and effecting universal harmony—the impress on creation at the very fountain-head of the two essential attributes, the immutability and the unity of Him who inhabiteth eternity and is the Author of all —the law of assimilation is the most deeply-piercing and all-pervading law of the cosmos that can be reached at present. It is, in fact, exactly an articulate expression of what all men feel when they think of Being and System.

"To find the place of the vegetable kingdom in nature, it is only necessary to consider that diffusion, osmose, capillarity, &c.—in one word, mutual penetration—does not take place between gases only, nor between liquids only, nor between solids only, nor yet between solids and liquids only, but also between aeriform and concrete media. It takes place between the air and the earth, the atmosphere and the soil, on their mutual confines. Yes; the air in contact with the earth tends to penetrate the earth, and to become assimilated to it by assuming a condensed or concrete state; while the earth in its turn, on the confines of the air, tends to rise into it, and become as aerial as it can. Nor can either do otherwise if the law of assimilation be as universal as it has here been maintained that it is. In obedience to this law, those earth-particles which are capable of the aeriform state must tend to rise into the air as gas or vapour; and those which are not volatile, yet separable from each other, must tend to effloresce into the air, and to constitute, on its confines, with the earth, lace-like mineral tissues as highly diffused, as spreading and elastic, as mobile and coloured—in a word, as aerial and bright as possible. I say bright as well as aerial, because the atmosphere is the realm of light and colours as well as of air.

"Has, then, let us ask, this cosmical disposition on the part of these great neighbours, the earth and the air, to keep the law and live in harmony together, to interlace their borders, and adopt as far as possible each other's substance and forms on their common frontier, been permitted to realise itself? Do we find that, on the mutual confines of the air and the earth, the air-particles seek downwards and become concrete; while the earth-particles, water included, seek upwards, and spread themselves abroad in the air? Yes; it will be immediately granted that the soil absorbs and retains in it a goodly portion of air and vapour. The earth also, it will be admitted, the more fully it is exposed to the air, becomes more and more pulverulent—nay, often rises in clouds of dust; nay, of fish; nay, of frogs; nay, what not, utterly to astonish the natives by their fall again. Certain earth-particles, also (potass, lime, &c.), in places where the air is still, are well known to effloresce beautifully into the atmosphere, as if to anticipate vegetable nature. Moreover, the aqueous matter of the earth is ever tending to rise into the air as vapour. Yes; it is to the law of assimilation (as the rational cause) that we owe the existence of the cloud-world, so varied, so grand; and not less benignant than beautiful. For when it exists as vapour in the air, it is no less under the law of assimilation than it was when in the earth as water. And, in consequence of this having now gained the aeriform state, and satisfied the demands of the atmosphere, it is called upon by the earth to satisfy its demand under the same law, and to become assimilated to it in its turn—that is, to become concrete. And, accordingly, with prompt obedience, from its aptitude for the concrete state, the cloud-matter forms into little masses while yet on high; and pouring down as rain, and hail, and snow, it not only assimilates itself with the concrete earth as a concrete form, but it ploughs the bald surface into many a ravine, thus enabling the air to penetrate deeper and lock with the earth more closely. Meanwhile the earth, by secular upliftings, meets the cloud half-way, and, summoning to its aid the volcano and the central heat, rises high in Alp and mountain-range, keen air piercing into the deep valleys between. Thus that which to blind sensibility seems but the war of the elements, is to intelligence a harmony and a mutual embracing. The storms and convulsions of nature are the products of a law which has repose for its end and aim, and which is, as has been already stated, the symbol and representative in nature of the unity and immutability of the Deity. The law of assimilation by which a wound granulates and our organisation is redintegrated, by which our strength, physical and intellectual, is restored from hour to hour, is also that by which the surface of our globe, from being a bald geometric surface, is made rugged and hoary—that by which the beautiful, the picturesque, and the sublime are imparted to nature, and a sheltered dwelling-place secured for man and other animals.

"Nor is this all. By the miracle of creation at first, and by sowing the surface of the earth thereafter, with the seeds of plants, the Creator has enabled the earth and the air to fulfil the law of assimilation and harmony between them in a manner that is most complete and most beautiful. *For the fully-developed seed, the individual plant, the vegetable kingdom as a whole, what is it, when viewed in relation to the atmosphere, but air become concrete as vegetable tissue piercing down into the earth and rooting itself in it? And, viewed in reference to the earth,* *what is it but a system of earth-particles, aqueous, gemmeous, earthy, saline, suspended and diffused in air to the utmost by the concrete air-tissue (that is, the vegetable tissue) as a scaffolding; these particles, meanwhile, in so far as they are capable of the aeriform state, exhaling into the air in forms often fragrant, and always more aeriform than those in which they enter the plant?* Yes; the calling of the vegetable kingdom, the charter of its existence with antecedent nature, the earth and the air, is to realise and fulfil the law of continuity, of harmony, of assimilation, on their mutual confines, (1) to carry up in forms as aerial as possible earth-particles, and to suspend them in a state of diffusion in the air when they cannot be made to vaporise into it, and (2) to carry down, in forms as concrete as possible, air-particles into the earth.

"And in this theory (along with that which gives the spherical superficies as the most general archetype of all forms that are the products of the physical forces*) we have a satisfactory explanation of the forms of the plant-world in general. Here we see why a fully-developed plant must consist of an aerial and a terrene part, of widely-spreading morsels of surface or leaves, supported, if need be, on radii as leaf-stalk, branch, and stem, and of deep-striking roots and rootlets. There is no longer room for wonder why plants and flowers, things of such beauty, should be so fragile and so fading, the sport of every blast. The plant-form must intercede between the fickle fleeting air and the fixed earth on their mutual confines. The plant must bring these heterogeneous elements together and reconcile them. And therefore, inasmuch as the air is very tenuous, elastic, mobile, spreading wide and rising high, while the earth is concrete, inelastic, fixed, and lying low, the plant which is appointed to represent both in itself, and each favourably to the other, must have a form that shall be tenuous, mobile, elastic, carrying up and distributing in the air such earth-particles as are capable of isolation and solution, as widely and as high over head as possible. It must, as an individual, be a wavy, fleeting thing. If it is to acquire stability, and to last for years, or generations, or ages, it must consent to the compromise of its individuality. It must have recourse to the principle of association. Many must merge into one. The phyton must become a branching plant or tree.

"That the plant-form, especially when an annual merely, must, from its tenuous and expanded character, be very liable to injury, is an inevitable consequence. But in creation, as it actually stands, is this an evil? Nay; to the very extent that the plant-world is easily destructible, it is suitable as food for a higher order of beings—beings

* See *First Lines of Science Simplified*, &c., by the Author. 1860.

possessing sensibility, and that sensibility so adjusted to their organisation that a state of organic well-being in them is a state of enjoyment to them; beings teeming in multitude—creatures such, that it may be truly said, in a high sense, that after the glory of the Creator himself, creation exists for their sakes.

"To our theory there also attaches a definite conception of plant-life and function. A plant, according to what has been shown, consists at once of an ascending and a descending system of parts and action; and for the full development of the plant, a corresponding amount of energy must be simultaneously imparted to both these systems and modes of action. If the proper earth-particles which it is the duty of that species of plant to raise and suspend in the air are wanting in the soil where it is put to grow, the plant has nothing to do, and it will not grow either well or long. And if light and heat, which energise the air, are wanting, all the peculiar phenomena of vegetable synthesis must fail.

"The ascending system of parts and action commences in the soil, and from concrete molecules in contact with the spongioles of the root, it takes up such as it can, analysing and reducing them more and more towards the purely aeriform state; thus resolving water into common vapour, common vapour into oxygen and hydrogen, ammoniacal compounds into ammoniacal vapour, and ammoniacal vapour into nitrogen and hydrogen; also decomposing carbonic acid into oxygen and carbon, at least if nascent hydrogen be present, so that the carbon, by union with the hydrogen, may be rendered more aeriform than it is by itself, and thus may form the basis of some Essence by which the fragrance of the vegetable kingdom may be added to the vital air which, in these circumstances, that kingdom must constantly tend to evolve. Add to these things and to this mode of action the elevation out of the earth towards the periphery of the plant, that they may be diffused and suspended in the air to the utmost, the fixed earth-particles of carbon or diamond, potassium, silica, phosphorus, calcium, sodium, magnesium, sulphur, iron, &c., and it will be seen how much the root-system of a plant has to do.

"But, for success in the accomplishment of this analytical function, it is wholly indispensable that the descending system which originates in the air and belongs to the leaf shall co-operate in energy; for as the ascending or leaf-system is essentially analytic, or in the interest of aeriforms, so this, the descending or leaf-system, is essentially synthetic, or in the interest of concretes. An atom of carbon will not leave those of oxygen with which it is combined in carbonic acid merely to fall down and clog the plant as soot. While the root-system solicits the oxygens and carbons to part company, and offers nascent hydrogen for union to both, it is the descending, the leaf-system, that which has light and heat as its energising principles, that actually effects the exchange. The leaf-system calls for molecules still more and more highly compounded, for the construction of which, above all others, hydro-carbon is well suited. But how, it may be asked, shall highly compounded molecules be able to maintain their existence if originating in the leaves and destined to encounter in the plant the analysing system of action that is ever ascending from the roots? For this they must be able to fulfil one or other of these two conditions: *first*, they must escape out of the cells in which the analysing plant-action is going on, and get into places or vessels apart; or, *secondly*, they must possess in themselves molecular stability while in the plant. Now, under one or other of these two conditions, it may be shown that all the permanent products of vegetable nature fall. Wax, one of the mostly highly compounded of them all, even often gains the outside and reposes on the leaf or the fruit, as does also sugar sometimes. All essential oils, resins, alkaloids, crystals, &c., exist in cells, apart; while as to starch, it is a vegetable substance constructed in such harmony with the whole action of the plant, that it is no more to be expected that a fully-developed plant will break starch up, than if it were the acknowledged embryo of cellulose. It is otherwise with sugar. But these views cannot be followed up by the ordinary lights of the laboratory. With the single exception of the sugars, all the formulæ of the tectonic elements of the vegetable kingdom are uncontrolled and destitute of significancy.

"Thus it is not the external forms and the chemical composition of the vegetable kingdom only which our theory explains. It throws great light upon the internal structure of plants. It not only leads us to infer that all the first and simplest plants, and all the first elements in every plant, shall be little hollow spheres—that is, cells, vesicles, or utricles; but it leads us also to expect that, as soon as this cellular mass can claim individuality, and constitutes a plant at once aerial and terrene, with both a descending and an ascending system, and therefore a combining or concreting, and an analysing or rarefying mode of action accompanying, the cellular matter, under the influence of the descending mode of action, commencing in the foliage, must, as it proceeds downwards, tend to concrete and combine into forms more and more continuous and dense,—as, for instance, into vessels, fibres, and encrusting matter, still increasing in quantity as we approach the terrene part or root. Under the influence of the ascending, the separating, and rarefying system, on the other hand, the mass of cellular matter must continually tend to separate and expand into laminæ, or leaves and cells with their walls, still more and more bright and aerial (as in blossoms in particular and parenchyma and the epidermis generally).

"Under the same state of things, it follows that the distribution of woody (or concrete air) matter and of ashes (diffuse earth-elements) in plants and trees shall be the converse of each other. The woody matter, as the product of the foliage, and of the descending concreting system, will be found in greatest strength in the interior of the stem and root; the ashy matter or earth-particles, the product of the ascending system, in the periphery of the stem and of the entire plant or tree.

"That all these deductions from our theory are verified by observation, is too well known to require to be stated; and here let us conclude with a remark suggested by the last inference, which throws light upon a great question in high philosophy.

"It is well known, in accordance with what has just been shown, that plants and trees are aerial and light above, massy and strong beneath. Now, this fact in creation has usually, in common with others of the same order, been held to be fully explained by a reference to its expediency. It has been said that plants have been wisely made light and aerial above, solid and tough beneath, to the end that they may be able to support themselves and brave the storm. Now this undoubtedly is a good explanation so far as it goes; but from what has preceded, we find that it does not go to the root of the matter. From what has preceded, we find that the lightness of trees above and their solidity beneath is not a particular expedient adopted in their interest alone, for securing a special end in their behalf alone. We find that it is secured in the fulfilment of a grand principle—that it is provided for in an all-embracing law, in the framing of which this particular end and innumerable other beneficent ends were provided for. These ends may indeed be advantageously contemplated by us in detail as such. But if we are to look for such ends in every individual object in nature and in every organ, we are only preparing ourselves for frequent disappointment; for utility is not the point of view which ought *to rule* in our regards. In the natural as in the moral world, there is a higher principle than particular expediency or individual interest. There is a call all through nature, which is ever for order, universal order, the well-being of the whole. And accordingly there is in natural science a doctrine of *general homology* as well as of *special utility*. And truly wonderful it is to observe to what an extent, in the natural as in the moral world, multitudes of special uses and individual advantages in detail are secured as often as supreme law is obeyed. Hence the grand aim at once of science and philosophy ought to be, the discovery of supreme laws; and to this theme the preceding pages have been devoted in the delightful field of the vegetable kingdom."

CHAPTER XIII.

OF THE FORM AND STRUCTURE OF A FLOWERING PLANT.

It was subsequently to the publication of these papers which have been so largely quoted in the preceding chapter, that I first ventured to conjecture in my own study, and have now come to believe in the structure of the material element, which has been set forth in these pages. It is for us now, therefore, to compare that supposed structure with the observed structure of plants, and to see whether we do not discern in the very structure of the material element itself anticipations of what we already find in the vegetable structure.

The vegetable kingdom, in order to be understood, must be regarded in a twofold point of view, which may be designated respectively as physical and physiological (or more correctly biological). The physical point of view regards it as the intermedium between the earth and the atmosphere, embodying and representing both, and clothing the planet with living objects, in fixed situations, which the sunbeams may fall upon and expand, fructify and animate. Otherwise, it may be also regarded as an efflorescence of the sphere mimicked by the efflorescence to be seen on damp walls, nitre-producing fields, and hoar-frost generally, a nisus of the planet to extend its dimensions as reaction against that contraction of dimension which the secular gravitation of its constituent particles implies, and so to utilise the heat which is constantly being forced outwards. This conception of the vegetable kingdom gives it as consisting of vertical lines or a continuation of the terrestrial radii into the atmosphere. It gives the plant as an axis fixed in position. It gives the plant axis.

The biological point of view gives a conception which is precisely the converse. For this point of view gives that of an organism which shall concrete the carbonic acid emitted in the aeriform state by the animal kingdom, and expose that concrete in the amplest manner to the sunbeam, to the end that the carbonic acid in it may be resolved, first, into oxygen gas again, so as to sustain the respiration of the animal kingdom, and, secondly, into carbon-containing tissue, so as to repair in animals the waste which respiration and action generally imply. Hence the vegetable concrete must be so formed as to expose as large a surface as possible, both for the most successful absorption of the carbonic acid that is floating about, and for exposure to the sunbeam or light of day, that that carbonic acid may be decomposed. In short, the biological point of view leads to the conception not of the plant axis, but of the leaf; not of the radiating stem, but of the foliage. The first point of view gives the axis, the other the equator, which, as is well known, are the skeleton of the sphere. And to what an extent the spherical tends to prevail in the vegetable kingdom has been already shown.

And now let us enter into some details. And as the anticipation of an elemental plant-axis, let us prelude with a structure consisting of three material elements united in a line. This is the smallest number in which individuality can be maintained; for it is the smallest in which the terminals are similar to each other, and therefore repulsive of each other, as also of others like them, and so can maintain itself as an axis, and not turn round into a triangular or circular form.

And as that of most easy genesis, and therefore most probable in nature, let the two terminal elements be those whose nucleus consists of 12 aetherial units, with 20 overlying them; while the middle element is of the other kind—that is, with 20 internally and 12 overlying. Now may we not remark at once, that in this simple structure we have already a preluding of the three parts, namely, fruit and root, with foliage lying between? Nay, more. Of the three elements, though all of them are intimately bisexual, yet, according to what has been advanced in a preceding chapter, the two supposed terminals are female as compared with the middle element, which is male. And here may we not say, what all the world grants, that it is fruits and roots which are productive of offspring as compared with foliage?

But according to prevailing tastes in science, it is more in order to say that a simple plant, when fully developed, consists of these three parts, the fructification above, and the root below, as terminals of the axis, and foliage lying between.

And, first, let us direct our attention to the fructification, in which, as it is free to uprise in the air and sunlight, individuation and ample development most fully appears; while the root, growing as it does in the soil and darkness, has to encounter continual embarrassments. Here, then, let us call to mind that the material element respecting which we are now to inquire whether the fructification of plants is in any measure preluded by it, consists interiorly or nearest the axis of 12 elements, and is here female in relation to an external layer of elements which are 20 in number, and male in relation to the others. Now that typical flowers are bisexual, as our material element preludes, and that the female parts are next the axis, and the male parts disposed exteriorly or around the female parts, are most familiar facts.

Being to such an extent encouraged then, let us enter somewhat more minutely into the investigation. But here the difficulty meets us, which at this moment prevails through the whole domain of natural science, namely, our utter want of insight or ideas to enable us to say what is what. Science is not only very blind, but glories in its blindness. What has been observed, it is said, is everything; what has not been observed, it is said, is nothing. Such is the canon of reality. And after all, the fact is that this boasted observation is in every case merely interpretation, the entire value of which is regulated by the culture or no culture of the mind which receives the sensations, or, as it is said, "observes." In the present case the question is, what are really female parts in a perfect flower, and what are really male? To this no answer has as yet been given which is comprehensive of all the parts. Nor has any scientific view been given of what makes male, what female. But may we not say, that of "female" the characteristic is to be receptive, and of "male" to be communicative. As to the forms of sexual organs, when we look to the whole of living nature, they are so varied, both in structure and situation, and indeed in every respect, that no definition can be built on form; we can only look to function as has just been done.

Applying this test then to that organism which forms on the summit of a simple plant-axis, that is, the flower bud, we remark that the whole at first presents itself as a sphere or spheroid, or rather ovoid, as perfect as the mode of its nutrition (which is from one region only) will allow. Now, viewed in this state as a whole, a calyx with its contents, it is female; the calyx being receptive in a twofold sense—receptive with regard to its interior of the whole fructification which lies undeveloped in it as in a womb, and receptive with regard to its exterior also; for the exterior of the flower-bud or calyx is usually of a green colour, contains chlorophyll, and is receptive of the carbonic acid of the ambient atmosphere. The calyx, therefore, we regard as belonging to the female parts of the organism of the flower. That the carpels, with their intensely receptive stigmas and ovules, do so is generally admitted. And thus we find that the parts immediately around the aerial terminal of the plant-axis are female, the sepals and the carpels being both analogous and homologous parts.

But our theory, that these parts are possibly preluded by the interior parts or endosark of our material element, ought to enable us to go farther. It leads us to expect that those parts, taken together with the axis which they surround, will, in a complete but simple flower, be precisely 12 in number, and these disposed in either of two arrangements corresponding to the two kinds of axis which the dodecahedron possesses. Of these two kinds of axis, one terminates above and below in a point formed by three edges, facets, or members of the polyhedron, leaving other three outside of them above and below alternating with them (see fig. p. 67). The other kind of axis has one facet or member for each of its terminals, with five members lying around outside of each, and these alternating with one another. Hence, according to our preluding, the normal number of calyx-divisions or sepals, or of ovary-divisions or carpels, ought to be 3 or 5. Now that nature verifies this anticipation to a remarkable extent will not be denied. It were possible, indeed, to carry the correspondence into a great degree of minuteness. But we are at present so completely in an ideal region that further details may be advantageously omitted here, especially as when the doctrine of abortion, non-development, partitionment of organs, &c., is introduced, there is no difficulty in squaring phenomena with the exigencies of any hypothesis.

Let us proceed then to ask now whether we find any correspondence in the number of elements in the outer layer of ectosark of our material element or element of true protoplasm, with those of the male parts in a perfect but simple flower. And here we have first to remark, that our protoplasmic parts are here not 12 but 20 in number, the 10 upper or interior being opposite to each other in couples, as also the 10 lower or exterior; but the upper 10 alternate with the lower 10 (see the diagram of the icosahedron, p. 67). Now were we to adopt the common view that the stamens only were male parts, the correspondence of nature with our theory would be abundantly verified, for the number of stamens in flowers are, in a vast number of species, 5 or 10, or 20 (or thereabout). But the view that the stamens or anthers alone are male parts, does not accord with the conception that the function of the male is to communicate, as that of the female is to receive. This conception includes the corolla also as male, and, indeed, the whole flower, except the calyx and carpels with their contents, as has been described. Thus, instead of being receptive of the carbonic acid of the atmosphere, like the calyx and the carpels when maturing and verdant, the corolla emits carbonic acid; instead of keeping the fructification cool by the decomposition of that acid and the emission of oxygen gas as the calyx does, the corolla, like the stamens, generates heat, which cannot but often be of great value for the maturition of the pollen. The corolla also plainly exists as a protection for the anthers rather than for the carpels, for as soon as the anthers have fulfilled their function and fade, the corolla fades immediately afterwards. The lower 10, therefore, of the 20 supposed male elements in the ectosark of the true protoplasmic unit we regard as preluding the 5 petals with their 5 claws, or the pentafid corolla with its tube, &c. The upper 10 alternating with the lower 10 we regard as representing 5 anthers with their 5 filaments, or possibly 10 stamens in many cases of development. Into further details and possible modifications we need not go, because the idea of a perfect, and at the same time a perfectly simple flower, is an idea merely.

Nor need we show, as must be under our cosmical law of assimilation (for this has been fully done already in an empirical way), that the flower in all its parts must tend to be foliaceous so far as the conditions of existence and the law of the spherical and cellular will allow. I only add, that the cosmical law explains also the great expansion of the corolla, for the corolla holds the position of equator to the terminal axis of the plant or peduncle.

As to the colours of the corolla, which have been held to be so beautiful, they are chiefly expressive of the absence of chlorophyll in it. Their charms depend on their comparative rarity, which engages and pleases the eye. If all the fields and forests were yellow, or blue, or scarlet, or parti-coloured, like flowers, what would we not give for a green leaf!

Let these remarks suffice on the structure of a perfect yet simple flower as preluded by the material element itself.

Upon the whole, such is the verification of our view which the vegetable kingdom displays, that instead of summing up our deductions as to the two sets of female parts in a flower with the two sets of male parts between and around them, may I not just quote the following words, which form the opening sentence of Professor Balfour's "Manual of Botany," where he treats of the flower and its appendages: "The flower consists of whorled leaves placed on an axis, the internodes of which are not developed. This shortened axis is the thalamus or torus. There are usually four of these whorls or verticils. 1. The outer one called the *calyx*. 2. The *corolla*. 3. The *stamens*. 4. The most internal one, the *pistil*. Each of these consists normally of several parts which, like leaves, follow a law of alternation. Thus the flower of *Crassula rubens* [he gives a diagram, which has been copied in fig. 16 of our Plate] consists of a calyx composed of five equal parts arranged in a whorl; a corolla, also five parts placed in a whorl within the former and occupying the intervals between the five parts of the calyx; five stamens in the spaces between the parts of the corolla and consequently opposite to those of the calyx, and five parts of the pistil which follow the same law of arrangement." Such is the example of a typical flower of this class which he gives. He adds,—"Again in *Scilla italica* the parts are arranged in sets of three instead of five," &c. It will afterwards appear, when protoplasm is regarded as differentiated into those organic elements which constitute the actual bioplasm of visible animals and plants, that there is another though an analogous reason for the appearance, now of the number 3 and its multiples, now of the number 5 and its multiples.

Having said so much of the fructification of plants as preluded by the uppermost of our three material elements which we conceived to represent the simplest plant-axis, very few remarks will be made on the root preluded by the lowest of the three. Being similar to the uppermost, though bisexual like the fructification, it is to be regarded upon the whole as female or productive. But here the organism, unlike the fructification which expands in the thin air, the root is so beset in the closely-resisting soil that the development is very poor and embarrassed. In fact, it all usually remains in a self-diffusing or filamentary state, the only specific organ being the open or absorptive spongiole on the top of the rootlets, corresponding to the stigma on the top of the carpels; the matter to be absorbed being, in the case of the root, free particles of plant-food produced by the soil around the spongiole; and in the case of the flower, free particles of plant-dust or pollen produced by the plant itself around the stigma; the former providing for the growth of the developing plant, the latter for the development of the future plant. On this subject I shall only further refer to a communication which I read before the Botanical Society of Edinburgh, 13th December 1860, which was, I believe, published in their Transactions, and, at any rate, in *The Edinburgh New Philosophical Journal* for January 1861, entitled "The Theory of the Terminal Fructification in the Simple Plant of Ovules, and Pollen, and Spores."

As to the middle member of our three elements in our plant-axis, which, of course, preludes the whole plant except the fructification above and the root below, nothing requires to be said beyond what has been said already, unless, perhaps, it be this, that while it is bisexual like the other elements, yet here the female parts are not internal as in the fructification, but lie on the periphery. They, therefore, prelude the foliage, which is at once peripheral and receptive or female—*peri-feral* to this extent that on it mainly devolves the determination of the external form of the whole plant, *and receptive or female* inasmuch as it has for its special function not only to suck in the carbonic acid of the air, and thus render the whole plant pregnant, but to form a bud or quasi-embryo, each leaf for itself.

CHAPTER XIV.

THE SIMPLEST ZOIC FORMS AND FUNCTIONS ARE PRELUDED BY THE STRUCTURE OF THE MATERIAL ELEMENT.

If we are to content ourselves with modern science (so-called) such as it is, though there is mystery on all hands, yet nowhere is there a spectacle more perplexing than that which nature displays in the field of the microscope. What multitudes of living things, call them protozoa, protophyta, or protista, or by any more special name, their forms, and even their skeletons, sometimes so exquisite, always so strange, and enjoying life surely,—those of them, at least, which move about so rapidly, so freely, so spontaneously, nay, shall we not say, so capriciously—and yet themselves, by all that the scientific eye (so-called) can make of them, merely specks of animated jelly or glue, without mouth or muscle, or nerve or organ of any kind! Their forms how strange, and their means of getting on how unaccountable, and how unlike anything which human ingenuity would have proposed for them! In a word, is not the entire field of the microscope to the eye, though enlightened by all that science has to say, a perfect mystery and a perplexity? Why in the last analysis do we meet with granules and cells on all hands and as the ultimate constituents of everything, both animal, and vegetable, and mineral? Why are these granules and cells at first, and so long as they are free and uncompressed, spherical? Why have cells, also, in these circumstances, usually a nucleus, often a nucleolus? And why do they come, manifestly after a delicate and difficult process of construction, to lose so soon these nucleoli, these nuclei, nay, themselves to be partitioned or to dissolve away? Those vibritile cilia, also, with which spores and ova, and the minutest organisms generally, are furnished as with banks of oars, and which seem to be so proper to every individualised organic element, that they are often found even where such element is impacted among others, and has only one free surface, and that in regions of the highest organisation, as for instance in the mucous membranes of man himself, what can their origin and meaning be? The tentacula, also, and lasso-cells, and setæ which succeed the cilia, as the organisms to which they belong become more complicated, and which characterise all the multifarious races of polypes, &c., how do they come to be there? Is not one tempted to think, if not to say, like that king of Spain when contemplating the Ptolemaic system of astronomy, that if we had been consulted at the creation we could have suggested something more solid and better? The fact is, that with respect to all these things, and a thousand others, nay, the entire microscopic field, nay, the whole field of nature, there is at present on the part of many naturalists nothing but despair, in so far as the rational point of view is concerned. To account for anything, they maintain is wholly beyond our powers, and therefore that with which we have nothing to do. Let us OBSERVE, they say, with all possible accuracy and minuteness all the objects which we can succeed in bringing within the range of our eye-sight. Let us CLASSIFY them all, and assign to each its place in nature with all possible painstaking, according to the best classification which we can devise, and let us turn to economic account, so that they may add to the enjoyments of our own life, those of them which are suitable for this purpose. But having done our best in this line, let us be content to let them otherwise alone. We are ourselves rapidly passing off the stage of existence like the rest of them. Why attempt to give an account to ourselves of the reason of anything since we are sure to fail? Why give any encouragement to hopes or fears with regard to a future, which though they have hitherto played, and still do play such an important part in the development and history of humanity, are nevertheless to all appearance needless and vain?

Such are the views of not a few naturalists at the present time. Nevertheless, to these naturalists, provided they are true to their method, and do not succeed in involving us in the same despair into which they have fallen themselves, have we not much reason to be thankful? For since they admit into their belief nothing but what they see with their eyes, they are surely good for us to go by so far as they go themselves; and if they have good eyes to see with, and good fingers to separate the objects they look at, surely their testimony as to what they have found must be of the greatest value. So it would seem. At the same time, it is worthy of consideration, how much more easy it is to profess to follow this method of simple observation than actually to do so. Nay, taking into account the unavoidable quickness and suggestiveness of mind in all who have curiosity enough to devote themselves to such inquiries, it may be questioned whether this method is ever practically followed in its purity. And, especially, it may be questioned whether this logically elected ignorance of the so-called man of science is much better than the natural ignorance of men in general. It is all very well to talk about accurate observation. No doubt it is the first essential to the discovery of reality. But after all, *observation*, as has been already stated, when it reaches the mind, though still retaining this name, is already *interpretation*, and its value depends entirely upon the mental culture of the observer. Now, how can we interpret anything in a satisfactory manner but in the light of reason? And how can we expect any interpretation of value, except from those whose minds have all their natural wits and intuitions about them? Now, among the foremost of these is a belief in God and in the intellectual system of the universe. A mind, therefore, which in this respect is either naturally defective, or by course of study, or of life, has eliminated from among its convictions these truths, which are among the most characteristic instincts of humanity, need scarcely be expected to see light anywhere but along those few lines of thought which, taken together in their focus, give an image on the retina. And where, let us ask, does this method, employing as it does the abnegation of the ceaseless afirmations and demands of reason, land us? What is that universe, the reality of which we are able to reach in this way? An irreproachable logic declares that, pursuing this method, what we find as possessing the highest and indeed the only certainty by way of external world, is nothing more than merely a possibility of sensations, and by way of ourselves, nothing more than a power or habit of spinning out these sensations into a thread of consciousness.* Yes, this and no more, for God and the universe, man and nature, soul and body, liberty and law, and everything! A possibility of sensation on the one hand, and a thread of consciousness on the other, that is all in all. Let us refuse, then, to indulge in such an unnatural and sterile suppression of reason. Let us rather listen to the anxious inquiries which she makes, and without an answer to which she will never be satisfied.

And to resume our development at that point where we have obtained the material element and the normal action of its aetherial atmosphere, supposing it to exist in a medium dissimilar to itself, and assuming that nebulæ or shoals of such beings or things do actually exist in that ocean of the universal aether in which we ourselves on board of this world of ours, and all other worlds, are sailing, do we find, let us ask, anything that throws any light on the forms and structures of those wonderful microscopic objects which have been referred to? Although, when we are at the material element only, we are as yet at an incredible distance from everything that is visible, let us not despair of finding resemblances. The cosmical law of assimilation, implying as it does a general homology among the products of nature, and especially among those which are most adjacent to each other in the order of genesis, leads us to expect

* See J. S. Mills' Criticism of the Philosophy of Sir W. Hamilton.

among the least and first things visible, resemblances in form and structure, and mode of action to the material elements themselves. Do we, then, find anything of this kind in the air which surrounds us, which of all earthly things resembles the æther most? Do we find in this medium any objects such that the material element itself of which they are composed may be regarded as a preluding of them? Now to this, though not altogether a negative, yet only an equivocal answer can be given. Until lately, indeed, the answer would have been simply, No. Until lately it was supposed that the common open air was free from particles of every kind, except those of the gases and vapours which compose it. But now it is found that even the azure of the sky, and at any rate a certain blueness which common air displays when properly illuminated for the purpose, is in reality nebulous in its nature, the nebulosity being due to clouds of foreign particles in the air. These particles are, however, so minute as not to be otherwise discernible at present. Nothing, therefore, can be affirmed with regard to their forms, structure, and modes of action. But in connection with them, the theory of zymotic and infectious diseases which is most in favour is to the effect that these diseases are caused and propagated by invisible organisms which, however they may have originated, and whatever they may be like, can maintain themselves all invisibly in the air for certain, sometimes lengthened periods. In confirmation of the existence of such objects in the air, it is also well known that media suitable for the entertainment of life—vegetable infusions, for instance, nay, chemical solutions, provided they contain the organic elements—cannot be long exposed to the air before they are teeming with life. And since the living beings and things which thus make their appearance soon produce on their own part spores and ova of exquisite minuteness, capable of producing their like in the same or other similar solutions, the legitimate inference is that they are themselves the development of spores and ova absorbed from the air. Their observation in detail while they are still in the air would, of course, be impracticable. But, all things considered, plainly in so far as the atmosphere is concerned, there is nothing to discourage us from searching even in this small planet of ours, to which alone we have access, for minute objects resembling in some respects, it may be, that with which we have peopled certain regions of the celestial spaces. On the contrary, there is much to encourage us to proceed with our inquiry.

Here, then, let us turn from the atmosphere to the ocean, and its various immediate or mediate distillates, that is, the waters generally of the terraqueous globe. In them, let us ask, do we find any objects bearing any resemblance to the material element itself, that individualised object or species which we have found as the very beginning of the material economy, where it lies on the very confines of the world of spirit, that is, of pure life? Yes, in reply to this it may be truly said, in general terms, that all the waters of the world—oceans, lakes, rivers, ponds, marshes, ditches, &c.—wherever there is nothing to prevent it, are all teeming with little beings and things all in motion, more and more of them still more and more minute being rendered visible in proportion as the magnifying power of the microscope is increased.

In this field, then, we may reasonably look for those moving forms which are simplest among such as are visible, with a view to mark whether there be any of them which still indicate resemblances to our primordial type of material nature.

It is true that when we have transferred our thought from the single material atom to any object which can by any means be rendered visible, we have, as has been already stated, taken a flight which, in point of interval, may be compared to the distance of our planet from the sphere of the fixed stars. The interval from a single unit of atomic weight to an object which is large enough to show anyhow in our eyes is inconceivably great. But still this should not, according to our philosophy, discourage us in a search for resemblances. For since, according to that philosophy, the material element and cosmical law are one and the same universally, nature must everywhere be consistent with herself, and resemblances between individualised objects ought never altogether to cease.

And hence, indeed, the possibility of a knowledge of nature, such as may be justly entitled to the name of scientific. Nay, hence a beau-ideal of the study of nature. For hence it follows that, by the acquisition of an adequate knowledge of any one typical and fully endowed object, a general knowledge of leading features in all is acquired at the same time,—a happy result, surely, for by such a state of things much of the life of the truly philosophical naturalist may be left free for higher pursuits than the mere classifying and naming of minerals, plants, or animals.

But to proceed. Among the simplest living creatures which become large enough in the field of the microscope to admit of any insight into them are, as has been stated, Gregarinida and naked Rhizopoda. The former, when fully extended, possess lengthened forms, but when they attain a state of repose, both become spherical, and are said to be "encysted," as represented in figure 1, which, as has been also stated, may also represent equally well the ovum of a highly organised animal. Here, then, we have an illustration of the cosmical law of material action, namely, that the spherical, as being the form of culmination under that law, is the limit of metamorphic action, and therefore the form of repose. And no less an illustration of the same law is the fact that the Gregarina, when in a state of action, departs from the spherical in form, and becomes prolate or axial, that is, spindle-shaped or cylindrical, while other species when active become equatorial, discoid, or radiate (Asteroidea), and multitudes hemispherical or hemiform (Medusidæ, &c.)

As to the Amœba (fig. 16) when in a state of activity, in its protruding in any or in all directions filaments consisting of the same material as itself, and in fact, parts of itself, and in its also retracting these parts again when and where it pleases, and thus out of its own plastic body or sarcode extemporising legs and arms for itself, and moving about spontaneously, and laying hold of its food, for the assimilation of which to itself it also extemporises a stomach,—in these actions of the microscopic animal, and in these protrusive and retractile pseudopædia, which are emitted from the protoplasmic body or nucleus, do we not see what we may call a nisus at repeating the structure and action of the material element itself, with its ætherial elements constantly proceeding outwards from the nucleus and returning in again? As to the Gregarina on the other hand, and Entozoa generally, such organism and action are not to be looked for in them, in consequence of the confinement which belongs to their habitat, which forbids all delicate projections from their bodies.

But more simple than these, and mirroring the single material element more expressly, we may regard those ova and spores, which the simplest organisms, both animal and vegetable, produce, multitudes of algæ for instance and zoophytes (see fig. 8). Add to these a vast variety of fully developed organisms, sometimes referred by systematic writers to the animal kingdom (fig. 14, Actynophrys sol.), sometimes to the vegetable kingdom (fig. 9, Volvox globator), many of them providing themselves with exquisitely constructed siliceous or calcareous skeletons or supports for their soft bioplasmic forms (see fig. 15, a Xanthidium or ovum of Crystatella); also Foraminifera and Radiolaria generally. While they are surrounded on all sides, or symmetrically, with fine sensitive filiform appendages always in motion, or tending to move, extensible or excursive and retractile, like the ætherial elements in the atmosphere of the material element itself, in none o these primordial animals, it is also worthy of remark, has a mouth been detected, any more than in the material element. There is no room for looking in them, therefore, for organs of digestion and assimilation. But these things we shall have to look for as soon as we proceed to consider the first stage of composition of organism, and thus make a step in the direction of visible objects.

That such composite structures are to be expected in nature, follows from what has been advanced, both as to the effects of respiration and of sexual differences. The former process we have seen to be exhaustive of the matter of the element or organism that breathes. Hence elements which have breathed much have become dissimilar to those which have breathed but little. When, therefore, two elements which are thus related to one another meet, they will tend, under the law of assimilation, to merge their differences by uniting together, and giving rise to a new structure consisting of a couple. Now, of this coupled element we may affirm these things. Its form must be lengthened or prolate. It must have one eminent axis, and it must consist of two parts, one of which is *materially* stronger than the other, but that other *ætherially* stronger than the first; for what a material element loses as to its materiality or inertia by the long-continued action of its ætherial atmosphere or respiration, it gains in what may be called ætheriality or quickness. Here then do we not find already in this organism, consisting of two parts united, the preluding of the body and the head of an animal, the body being the more material, the head the more ætherial part?

And what will be the mode of action of the ætherial elements proper to the two atmospheres of the material elements in this coupled form? Plainly the excursions of those which lie between the two component parts of the coupled structure, and therefore about the middle of the form, can no longer radiate and return freely from and to their proper centres, as they did when the two material elements were separate and free. On the contrary, as they tend to meet each other in direct opposition, their excursions will tend to strike out at right angles to the axis of the coupled form, and thus to form an equatorial respiratory circle. Not that this respiratory circle will correspond in position with the middle of the form. The law of action and reaction implies that it will be thrown by the part which is materially stronger nearer that which is materially weaker than the middle of the form, that is, nearer the head. As to the extremities of the axis of this coupled structure, the ætherial elements there will be more free to perform their normal radiant and returning excursions. Thus they will prelude cilia, tentacula, setæ, &c., at the head and tail. But here also the law of action and reaction will tend to endow the head more fully than the tail with purely material organs (tentacula, arms, &c.), while it will at the same time tend to arm the tail more fully with more ætherial elements. Now of these we have seen that germ and sperm are ultimate products, and therefore testes, ovaries, oviducts, stings, &c.

The structure, therefore, to which we are led as representing a living thing such as would result from the lasting union of two material elements, may be something like this (see fig. 17); *a* and *b* are the united elements, *a* the more ætherial, *b* the more material, and therefore *a* the head, and *b* the body. Projecting from *a* there is a complete circle of vibrating cilia, or setæ, or tentacula, or ciliated tentacula, &c.,

ministering to the preservation (securing food, &c.,) of the individual. Projecting from *b* there is a defective circle of cilia or setæ, &c., *d* ministering to the reproduction of the individual. Around the head or neck, or between it and the body, there is a circle of cilia, &c., constituting a respiratory apparatus, which considered as expiratory, is of course counterpart to the alimentary circle around the head, and therefore such that, if that around the head bespeaks a mouth, that adjacent to it, but beneath it, indicates an anus. Now, in such a structure do we not see the preluding of such living beings as many infusoria, wheel-animalcules, and polyzoa, cephalopoda, &c. ?

But let us hasten to remark, that although even a single material element (since its nucleus contains a central cavity), and still more, a couple when united, may represent an organism with a stomach, yet no development of a mouth has yet appeared, or any other need of alimentation but that which the emaciating action of respiration implies. As the living organism becomes more composite, however, a mouth, intestinal tube, and cloaca present themselves. Thus a coupled element consists of dissimilar parts. Hence such couples will tend to unite again, and there will result more and more lengthened structures of extremest simplicity, and either rigid, or capable of wriggling. And may not these be taken as the preluding of bacteria and vibrios in the first instance, afterwards of worms in general ?

But following the course of definite organisation, we are called upon to remark that, as soon as three coupled elements have united, thus implying two hinges, the structure is capable of obeying so far the law of sphericity, that it may bend round, and head and tail uniting, thus constitute an annular segment of a triangular complexion, consisting of six material elements, and possessing six systems of cilia or setæ, arms or legs, or projecting organs of some kind. Now, have we not here the preluding of the segment of a vertebra, or at any rate that of an annuloidal or annulose animal ? (See fig. 18, which is a transverse section of an animal of this order.) But each such annulus, being equatorial or discoid, they will, when developing in the same region under the law of symmetry, apply themselves to each other, so as to form a tubular structure, that is, a structure defective at both ends,—that is, having both a mouth and an anus or cloaca,—provided the organism be developed free in the medium in which it exists.

If, again, it be developed where the first ring is attached to any object, it will have a mouth only, and that surrounded by a system of cilia or tentacula, or ciliated tentacula, as the case may be. And here have we not a preluding of a polype in general, a conception which embraces the animal kingdom in its simpler members to a vast extent ?

And now we need not attempt to carry our zoic synthesis any farther though it was desirable to carry it thus far, because while we had the respiratory function from the first, and even from it saw the necessity of an alimentary function, it did not appear till now how alimentation adequate to secure growth and development, as well as to repair the emaciation implied in respiration, could be effected. Now, however, we see how this may be secured, when a structure defective at one if not at both extremites presents itself, that is, a structure with a mouth leading to an internal cavity, with perhaps an anus also.

But let us not attempt to carry our animated morphological constructions any farther here, when we are dealing as yet with the true, simple, or undifferentiated protoplasm, not the bioplasm of the biologist compounded of hydrogen, oxygen, carbon, and nitrogen, &c., but the mother element of all these, and of the whole material system. It is also to be considered that the aims of general or merely geometrical morphology, (symmetry and sphericity) cannot be in any great measure attained by organisms, which are obliged to develope under the manifold restrictions of concretes confined to the surface of our planet. Thus the gravitation of the planet requires that the axis of the form, if it be of any considerable size, shall be either horizontal or vertical, the former alone being stable. Hence, in individualised forms most frequently, a horizontal axis with a bilateral only, instead of a radiant symmetry, as in most animals; and in those whose axes are vertical, a verticellate and hemispherical (rather than a fully radiant and spherical form), as in most plants. The genial sunbeam also acting at the opposite pole in space to gravitation, tends to lengthen the axis upwards in all vertical forms, and to differentiate the dorsal from the ventral aspect of organisms. And in a word, it is only among forms on which gravitation and sunshine have but little effect, that is, among minute or aquatic beings, whether ova or minute forms, that an obvious accordance with the general types of morphology can be expected.

It is further to be considered, also, that there are in nature comparatively few, either plants or animals, which are truly individuals morphologically considered, few therefore which can be brought to the test of the general theory of form. It has been long known that plants which have more buds, or rather more leaves than one, are composite individuals. And the same is true to fully as great an extent, with respect to animals when morphologically considered. Thus a simple form can have only one equator and one axis. But most animals consist of many equators, which, however, being placed in a column with their axes end to end, preserve unity of axis and of animal life, whence animals have usually axial or lengthened forms.

An axial or lengthened form is indeed necessary to their activity; for sphericity is the form of fulfilled cosmical law, and therefore of repose. Hence it is aimed at by all animals with a long axis when they go asleep ; for in that case, they ever tend to form their axis as much as possible into a circle or coil. Hence, also, the life-long action of the umbrella of the medusa in the sea, and of the heart in the breast of the vertebrate. They are both more or less hemispherical or pyramidal, that is, half spherical only, and hence they never cease acting, and that always in the interest of sphericity. They are ever throwing the mobile matter on which they act to the other side of their base or equator, so as, if possible, to effect symmetry and sphericity,—in which, indeed, if they could succeed, it would secure to the elements of which they consist freedom from all future work, and their emancipation from the concrete into the aeriform state—to repose or dance in the sunbeam, till the call came to them to descend again and assist in constructing concretes again, to which our partiality is easy to be explained, since our own organs are of the number of such concretes themselves.

But to return. Pursuing the course of life in the preceding synthesis, I have proceeded at once from the biological preluding of a single couple of material elements, to that of three couples united so as to form a ring or an annuloid articulation. But here, may it not well be asked, shall a couple of single material elements be prevented from attaching a third, so that not three couples, but simply three units of matter shall form a circular system. It is certain that such a system will be stable in the highest degree attainable by three equal and similar forces merely ; for such a group forms the triangle of forces of statical science. And when to the three we add a fourth poised over the triangle at an equal distance from all the three, so as to form an elemental triangular pyramid or tetrahedron (see fig. Δ). Now this is a statical system of the utmost stability and intransmutability. But in the very degree that a material structure is stable and intransmutable, it is incapable of life. Here, then, we find the dead appearing among the living ; here we find our primal matter of creation, or true protoplasm differentiated, by the appearance in its midst of dead particles of an abiding molecular structure.

Δ

The Tetrad.

CHAPTER XV.

ON THE DIFFERENTIATION OF THE PROTOPLASM TREATED OF IN THIS WORK, AND THE DEVELOPMENT IN IT OF THE ORGANIC ELEMENTS COMMONLY SO CALLED.

In all that has preceded, mere or pure matter itself has been regarded as the basis of life in nature, and that which constitutes the true protoplasm, when we attach to the name its etymological import. It consists, according to our philosophy, of units, all of which, when entire and uncompressed, are spherical in form, and every way equal and similar to each other, except as to the positions which they occupy in space. In this respect each material unit is differentiated from all the others; and on this fact, according to what has been advanced, the whole economy of material nature, whether considered in reference to synthesis or analysis, growth or dissolution, depends.

But while all the material elements are equal and similar to each other, each is, according to our views, differentiated as to its own structure, composed as each is of an atmosphere or dynamosphere of æther, and a nucleus which consists also of æther, but in which the ætherial elements are confluent into one, which thus becomes a material element; the number of ætherial elements so confluent being $12 + 20 = 32$, giving as lines of junction traces of the two most perfect of the Platonic or geometrical polyhedra—namely, the dodecahedron and the icosahedron, either superimposed upon the other, or symmetrically circumscribing or inscribing it, as these two forms are well known to geometers to be capable of doing reciprocally.

This hypothesis as to the structure of the ultimate material element, which no one probably for a long time to come, save the author, will be disposed to admit to the rank of a discovery, or perhaps to regard otherwise than as a creation of an individual fancy, has been reached by invoking the aid of that law to which the name of cosmical has been awarded, because to it alone, ever operating under the eye and fulfilling the design of the great Creator, who is always and everywhere imminent to His creation, an appeal is ever made. If other physicists and naturalists indulge in laws of nature by the dozen, or the score, or the hundred, we admit, as the ground of them all, so far as they have a ground in nature, only one. And if by a constantly recurring appeal to this one, we can explain, and have in this and the preceding parts of this "Sketch of a Philosophy" explained, a far greater number of the phenomena of nature and the laboratory than have been explained otherwise by scores of laws, which are frankly admitted to be empyrical, surely this is no slight claim for our law to be at least looked into with a view to its acceptance or rejection. But let it not be forgotten that for any great step such as this long time is required.

This one law, which is regarded as cosmical, I have named the law of assimilation, because the process so named by which our living organism is maintained from hour to hour, is a familiar example of its operation. It is to the effect that every individualised object tends to assimilate itself to itself in successive moments of its existence, and all objects to assimilate one another. The ground of it is, that the created substance or simple and pure substance of creation, has for its special function to manifest the Creator, and consequently to assimilate itself to His will and attributes in so far as the finite can assimilate itself to the infinite. Hence it is, in its own nature, wholly plastic or devoid of fixed innate properties, and wholly assimilative, both with respect to its own portions or parts, and to surrounding objects, and to its position in space, and (in so far as it is capable) to the mind of the Creator. And thus there immediately awake in the material elements, as I have shown in the preceding parts of this work, individuality and the properties of sphericity, elasticity, and inertia, along with a tendency to be assimilated as to place, or, as is commonly said, reciprocal attraction.

Hence, in the first place, the construction in the æther or realm of light of groups of ætherial elements, generating material elements such as have been described.

Hence, secondly, a tendency in the material elements, when previously distributed in space, to form into groups, in which their ætherial atmospheres may become completely confluent, while their material nuclei, being possessed of a more powerful individuality than ætherial elements, come into juxtaposition merely, thus constituting molecules.

Nor is this all that can be ascertained respecting them. By two impregnable arguments, one of them mathematical, and compelling universal consent, the other a legitimate deduction from the cosmical law, and therefore good in our philosophy, the forms and structures of these molecules must always be as symmetrical as the reaction of their own constituent particles and that of their surroundings will allow. Now, to the full extent that mathematics can determine the forms of systems of equal and similar, elastic and reciprocally attractive spherical forces, or centres of force, when they have settled in a state of equilibrium, their forms are proved to be symmetrical in the highest degree. And the law of assimilation gives the same result; for symmetry is precisely the assimilation to one another of those parts or particles in a form, which correspond in situation on opposite sides of some plane or line or ultimately some one point in the form.

Moreover, this, which must be admitted to be a clear and distinct conception of symmetry, enables us to discover what is that form towards which symmetrical forms as such culminate; for that form must be the one in which the assimilation of the parts or particles in all situations are most fully assimilated to one another, and to a single point within the form. Now this plainly occurs in the spherical superficies or cell. And here, may I not ask in passing, whether all nature does not verify this conclusion, wherever she is permitted to do so? From the great orbs of heaven to the minims of the microscope, whether organisms or atoms of bruised granite, what have we, as the recurring form, but the sphere everywhere?

No; happily not everywhere, at least not the spherical and cellular in form, consisting of similar or homogeneous materials. For where that is the case in any object, the aim of nature in the construction of that object has been attained. Further activity in the previous direction has come to a close, and that object, viewed as it has been hitherto, has nothing to do but repose or to die.

Let it not be forgotten, however, that no sooner has death taken place on this account than the particles constituting the object, being now set free from obeying the law of assimilation as to *space*, and from constituting a part of a composite form (not their own), are free to obey this law as to *time*, and so to become again the individualised objects they were before aggregation, each entitled to occupy its own field in free space as originally awarded to it, that is, to become aeriform.

But though such a law there be, it does not follow that spherical and cellular objects shall meet the eye everywhere. As to objects placed on the surface, or anywhere out of the centre of a gravitating sphere (such as our world is), which is of course always drawing every material element towards its own centre, their construction by an aggregation of such elements into forms which are themselves spheres, especially cellular or hollow spheres, cannot but be very difficult, in many cases impossible, and in many indefinitely postponed.

But hence two most interesting results—first, a ceaseless and indefinitely continued activity in matter; and, secondly, a definite direction of that activity—that is, a life and a morphological aim—or, in one word, a definite economy of nature.

As to the character of that economy, when viewed metaphysically, it may be said to be the attainment of repose; and when viewed physically, to be the construction of the most perfect of forms; for such, under many points of view, the single-walled sphere undoubtedly is.

In this work I have first taken into consideration the structure and action of a single material element. And in the structure which has been assigned to it we have seen, as we should expect under the cosmical law of universal assimilation, implying as it does a homology reigning through all nature, the origin and cause of many of the first, and strangest, and otherwise most unaccountable facts in biology. Thus, in the *structure* of the material element itself, we have seen the type and prelude of such structures as nucleus and nucleolus, female and male, endosark and octosark, &c.; such organs as cilia, tentacula, limbs, &c.; such beings as locomotive spores and ova, Rhizopoda, &c. We have also found in the material element itself the reason why certain numbers are recurrent and prevalent in organic nature, both animal and vegetable. In the *action* of the material element itself also we have found a preluding of the grand function of respiration in general, and in detail an anticipation of such institutions as lasso-cells, various kinds of spitting and exuding, as also tegumentary appendages, &c., these things when looking to a single material element.

We have also, though very shortly, considered the case of two material elements united into one. And in this we have seen a preluding of such beings as infusoria, nay, much higher organisms considered as forms merely, as also the differentiation of an animal into a head and a body.

We have even touched upon the case of three material elements when united into one. And here we have found morphology opening into two branches, one corresponding to that in which the three constituents continue are united in the same line or axis, the other that in which they bend round upon the two hinges which the union of three implies into a trigonal or annular system. And here, corresponding to this deduction, when we looked to nature we found rising out of organisms which may be conceived to belong to either line according to their time of life, the vegetable and the animal kingdoms, the straight axis composed of three material elements superposed on each other, representing the plant-element, the annular system of three representing the true animal-element.

Such annuli, in fact, being applied to one another on the same axis, there is preluded that structure of the animal axis, which manifests itself almost from the beginning onwards even into the vertebrata, the highest of terrestrial organisms. The characteristic of the whole series is a continuously hollow or tubular body, which has two mouths, or a mouth and an exit-opening, or, at any rate, a structure which is in want of matter or food to complete its form.

And here the question arises—given our elemental annuloid, or mere triangle of matter, how can food be prevented from placing itself axially as two similar poles (for both are defective in matter), as the law of assimilation would seem to imply that it should; in other words, how shall the two open regions be differentiated, the one as mouth, the other as anus? This is a question very interesting, no doubt, but which it would be preposterous in us to enter upon now, while, as yet, we are dealing with homogeneous undifferentiated protoplasm, the primordial element merely, in which neither hydrogen nor oxygen, nor any of the organic elements, commonly so called, have, as yet, been secreted or have otherwise made their appearance. Before addressing ourselves to it, therefore, let us see what must happen on the simplest possible conditions, and while as yet, elemental synthesis, the demonstrated propositions of statical equilibrium, and the law of symmetry or assimilation may still be a safe and certain guide. This inquiry will, moreover, bring us into the region of well-known terraqueous substances, and first of all into acquaintance with

The Aqueous Element.

What we have to set out with in the biological point of view in which we are now contemplating the synthesis of material elements, is a system of three such elements arranged, not as a linear or axial system, but as bent round and forming a circular or closed system, the extreme stability of which we have already seen when it was statistically considered as the triangle of forces, but which we now consider as an elemental annulus or element of a flexible tube or annuloidal body.

And here we have first to remark, that two such triquetro-annular bodies meeting in the same field will conjugate; for a couple in union on the same axis, viewed in reference to the ætherial atmospheres, now supposed to be resting on each other, must be more nearly spherical than one only, for one is merely an equatorial ring, whose form overhead (that of its atmosphere) must be a very oblate spheroid.

But before they conjugate such Desmidia-like elements must also exist single at least for a time.

In a mass or medium, then, consisting of true protoplasm, that is, of merely material elements, not differentiated otherwise than each is in its own intimate structure, let there be developed a greater number of conjugated trigonal annuli such as have been described, and along with them a smaller number of similar annuli still single. Of both it is to be observed that they are similarly defective in matter on both extremities of their axis. But this defect, a single material element or particle of protoplasm, by placing and poising itself symmetrically over both ends of the axis in both cases, can supply in perfection. There will thus be developed two molecular structures, the nuclei of which we may thus represent in diagram and literal symbol.

♅

H

I have elsewhere shown (see P. II. p. 46; P. III. p. 14) that both these bodies, if free, must be intensely stable, undecomposable, and untransformable and what they represent in the laboratory. But what we have here to remark is this, that by their secretion thus, in the course of a biological synthesis or growth, these two bodies call a halt in the march of universal life. For when we say of an individualised structure, that it is alive, what we imply is that it is unstable or mobile, decomposable, transformable. Our ♅ and H, therefore, which are similar to each other in many respects, are similar also in this that they are dead, at least when considered as existing alone and free, and at such temperatures as are to be found on the surface of our planet. This limitation as to temperature is necessary with regard to H, for, although, when free it must always maintain the form of a trigonal bipyramid, yet it is also capable of assuming what may be called a coronal form, in which its five constituent units come into the same plane, defining the five points or angles of a pentagon. On this, however, I need not enlarge here. But while ♅ and H are similar, they are also dissimilar to one another, and this it is important for us to remark. For, hence, they will tend to unite together! And since atoms of ♅ are more abundant than atoms of H (for of all stable structures the elemental tetrahedron Δ is the simplest, and ♅ is merely a symmetric couple of elemental tetrahedra) atoms of ♅ will gather around atoms of H. As to the resultant combination, that will obviously depend on the number of regions in the atom of H, which are suitable for the attachment of atoms of ♅. Now these regions are obviously 5, three on the equator and one on each of the two poles. As the product of the aggregation, therefore, of H and ♅, we shall have a combination, which is expressed by the formula—

H♅^{5}.

It is so polymorphous that it would take long time to describe and many diagrams to show the various forms in which it may possibly exist. But there is one of these which transcends all the others in symmetry, sphericity, and compactness, and therefore in stability under trying conditions of existence. This, therefore, we may regard as the natural and characteristic form, at least when the temperature is not such as to develope the most highly-expanded form; and this we may regard, therefore, as the biological form. It is when all the six constituent members of the structure place themselves so that their equators are all in one plane, an equatorial angle of each being in the centre. They are all nearly isamorphous, and the equator of each is an equilateral triangle. The equator of the group is therefore a regular hexagon, composed of six similar triangles. And over each of them in both sides a material element is symmetrically poised, giving to the whole a structure of exquisite symmetry. But it is as defective on its axis as are the original annuli or triangles of forces of which its equator consists, or, as we might say, it has two open mouths. Also, instead of possessing a cellular or centrally empty structure, its centre is its most loaded part. Symmetrical and beautiful, and in some respects perfect, though it be, therefore, it cannot be an ultimate as well as a primal element in nature. Meantime let us here give its diagram and a literal symbol (which we will afterwards justify).

aq.

But what have we here? This structure the iron hand of a synthesis, guided by the inexorable laws of statical equilibrium has forced us to construct and to accept. And to it we must reconcile ourselves, however strange and unlike anything that we meet with in nature it may be. But is it strange, and unlike anything in nature? Nay, can any one look upon such a structure without being reminded of the first concrete forms of the aqueous element—that element which, by the vaticination of all philosophy, has been deemed to be primeval? What will result from the symmetrical aggregation of such structures but the actual forms of snow flakes? Are we not also reminded by it of the

Snow Flakes.

flowers of endogenous plants, that is plants in which it may be said generally that the aqueous prevails over the carbonaceous tissue?

Endogenous Flower and Seed-Vessel.

But these resemblances by the way at present. Here let us ask, in the first place, respecting it, whether, supposing a multitude of such to exist in the neighbourhood of each other, they will continue always to exist separate, or whether they will not rather, under increasing cold or pressure, run together into a molecule of some kind? That the latter alternative must represent the case may be gathered from inspecting the form of the structure itself. Thus, of the six parts which constitute it, one is an atom of H, while the other five are atoms of H̥. The structure is therefore differentiated, and in virtue of this, as an individualised body, it will cohere or continue in union all the more firmly.

But, for the same reason, one of the six sides of its equatorial region, or region for union, is dissimilar to the other five. Hence, when two or more, through cold or pressure, come near enough to one another they will assume positions in relation to each other, such that the repulsive action of the similar elements shall be a maximum and in equilibrio, and the dissimilar elements, consequently, nearest to each other, and most favourably placed for clapping together as soon as the ætherial atmospheres of both, or of all, will permit. A medium then containing sparse atoms of aq will be liable to change, and an aeriform medium composed of such atoms will, under increasing cold or pressure, tend to condense. And, plainly, it would be a great step if we could ascertain the forms and structures which will result. We have this to guide us in the inquiry that, as to the resulting molecules, like all others, they must tend to be spherical.

Now, here we are met by the fact that the equator of the molecular constituent aq, which is obviously the region of quiet or cool union, is a hexagon; while this is such a form that, when hexagons are continuously united together, they cannot form a definite polyhedron at all, but only a linear series or lamina.

Here, then, we find the first differentiation of an undefined mass of protoplasm which our philosophy gives. From having been homogeneous, it will now lie traversed by lines and laminæ, and, in fact, be differentiated into a tissue consisting of true material elements held together by fibres and membranes of aq. And have we not here the preluding of those jellies, both vegetable and animal, of which, when the contained aqueous matter goes off, almost nothing remains, however large they were before?

But differentiation and individuation must tend to go on. The atoms of aq must tend to segregate, and thus to grow together under the law of symmetry, and become individualised as they may. And here let us ascertain, if possible, what must be the form and structure of the smallest number which possesses good morphological conditions of existence. Recurring to the lamina (which it is the characteristic of hexagons when grouping together), the smallest which fulfils the condition of symmetry is when 3 place themselves on alternate edges around one in the centre. And when on this central one, other two place themselves one above and the other below, so as to form an axis of 3aq to the lamina of 4aq as the equator, we obtain a molecule which has a certain claim to existence. It consists of 6 atoms of aq, 3 ex-

$AQ = aq^{36}$

panded laterally like petals, and 3 standing in the axis like an ovary, each composed of course of six parts, so that it may be regarded as a distant preluding of a monocotyledonous, say an alismal flower. But such molecules, consisting of 6aq each, must tend to run together again, and that in groups of six again, as the smallest number that the law of symmetry permits. And now having obtained a group of hexagonal structures, consisting of six times six members, they may attain to a higher unity and at the same time develope an exquisitely spherical molecule of a capsular nature constructed of six ribs or meridians, each consisting of 6aq, and united with one another at both poles. See on p. 144 a very defective diagram of it.

Here then, in our protoplasmic body, already differentiated inasmuch as it contains filaments and laminæ of aq, though, like itself, wholly hyaline, we find a tendency to a further differentiation in the construction within it of molecules or spherules of AQ = 36aq, which, no doubt, as to the eye will be equally hyaline or transparent. Now, in such a structure of the whole, have we not a preluding of the structure of such protoplasmic beings as sponges, &c.?

And now, suppose one of these contained spherules of AQ to leave the body in which it has been generated and to exist free, let us ask by what generic name we shall call it. And, in the first place, shall we regard it as inorganic or organic, as dead or animated?

That it must be held to be of an organic rather than of an inorganic structure follows, I think, from this, that it is a truly individualised body, constructed symmetrically, its exterior dissimilar to its interior; by which last feature it is distinguished from a crystal or crystalline element. But instead of pressing this inquiry further, since the idea of organisation is always associated with that of life, let us ask whether we ought to regard it as dead or animated. Now, here again we are troubled by the same indefiniteness and obscurity which attaches to the use of terms of everyday life when transferred to exact science; who knows what he means when he speaks of the difference between deadness and animation? Let us not attempt to settle it. But giving up that to lexicographers, let us state some of the properties of our capsular structure AQ, and leave the reader to determine for himself the category in which he will place it.

Looking then to nature with a view to discover something like it, one is at first disposed to say that it is the very prefiguration of a Beroe with six ctenophores.

But a further inspection shows, that though the intimate action of the material elements, as the summits of the six times six atoms of aq, which form the meridians or ctenophores, may be very great, yet that action can only consist in vibration, or rather pulsation, all round the whole form, and that in the direction of radii to that form, or else in gyrations at right angles to these radii. That action can therefore only be calorific, not locomotive. But of such a structure as aq or AQ, it may be remarked, that the amount of pulsatory action proper to its constituent atoms, even at a low temperature, must be singularly great; in other words, what ought to be called its specific heat must be singularly great.

As to the form of AQ, it might also be shown that, according to the amount of pulsatory action or heat which actuates its constituent elements, that form must be either spherical or oblate or prolate. It must be spheroidal, on opposite sides of the spherical, corresponding to risen or fallen temperatures, and therefore its volume must be a minimum at a certain temperature, namely, when AQ is spherical, with increase of volume both above and below that temperature, a state of things which reminds us not of any organic form commonly so called, but of water, which, however, usually constitutes not less than $\frac{3}{4}$ of every organic structure, and often a great deal more, sometimes almost the whole, as in Beroe, &c., already alluded to.

But in all this, whether its great amount of specific heat, or its changes of form with changes of temperature, there is nothing that would warrant us in regarding it as animated. Life implies the power of internal change, without dissolution, to a far greater extent than this. And if it imply dissolution also, then that, not without the previous or simultaneous production of spores, ova, or embryos of some kind, which may reproduce the life of the parent.

Now, this power of reproduction, which has been commonly regarded as a characteristic of life, we have here in perfection. Our AQ at a certain temperature or on diminished pressure breaks up in 36 atoms of aq, which separate from each other. And may not this be regarded as a preluding of what is seen to take place often in animated nature, as, for instance, in the mature monad, when it breaks open and gives birth to a multitude of little ones?

But is AQ capable of such change of form as may be observed in species all through living nature, whether plant or animal? This is the question for us now, most interesting, not so much for the solution of the question whether we are to regard AQ as in some sense animated (which after all is very much a question of words), as for bringing us to know what AQ actually represents in nature.

And here plainly, in the first instance, we must direct our attention to the atom of aq, by 36 of which a molecule of AQ is constructed. Now, this aq we have already seen to be composed genetically of two somewhat similar structures, namely, H and Ħ, and to be the product of the complete saturation of H by ♅ in its most symmetrical form, the equation being—

$$\text{H}\ ♅^{5} = \text{aq}\ .$$

Now, though aq (see the diagram, p. 142), in virtue of its differentiated structure, cannot but be possessed of a certain amount of stability greater by far, for instance, than would be possessed by a similar form if composed of $♅^{6}$ or H^{6}, yet it is obviously tender. The atom of H in it is not symmetrically placed in reference to the 5♅. Moreover, aq is wholly deficient in an axis. Hence, if 5♅ be capable by themselves of constructing a symmetrical and stable molecule, while one atom of H may form an axis for it, such a transformation of the atom of aq may be expected often to occur.

To illustrate this, and to save the multiplication of bad diagrams, and to use types which are already in the hand of the printer, let us take ✳, a star of six rays, to stand for aq; also I or a dash placed vertically or horizontally, as it may be, to stand for H; and ∞ or 8, figure eight, horizontal or vertical, to stand for 5♅ in the new form, which, along with an atom of H, is anticipated from the transformation of an atom of aq. Thus we shall have as identicals in equivalent symbols—

$$\text{H}♅^{5} = \text{aq} = ✳ = \overset{|}{\infty}.$$

Let us suppose, then, that we are to follow the changes of the structure of the group of 6aq which we supposed to form the first step in the genesis of AQ, and that, when there is no more aq present, and when, consequently, AQ could not be developed. In this case we may use the symbols just adopted, for any kind of representation is very difficult to draw and expensive to cut in wood, or otherwise produce.

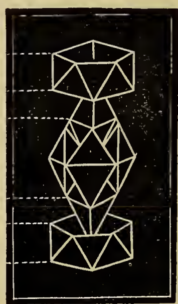
✳
✳ ✳ $✳^{2}$
✳

Three of the six atoms of aq are in the axis of the combination, standing on each other's hexpartite poles, the other three (only two of which appear in the diagram) form equatorial expansions or wings. The latter at present we may neglect. But looking to the former, and inspecting the state of this axis as to unity and solidarity, it may be easily seen that is very badly constituted. In fact, the sustained pulsatory action of the summits of the two extreme atoms of aq against the summits of the middle one and its action against theirs, must tend to throw the atoms of aq off from one another, and so to dissolve the structure. Now, such a dissolution would be prevented if in each of the two hollow or negative poles of the central atom of aq an atom of H were inserted; for in that case all the three atoms of aq would, in a manner, be bolted together. Now, such a position and purpose, the two atoms of H in the two extreme atoms of aq, in the structure of 3aq, can supply. But having supplied them, there is left on each pole of the structure not an atom of aq, but 5H in connection with one atom of H now in an axial position. Can these 5H then symmetise and construct themselves into a stable molecular element? Yes, that they can; and in either of three ways, whereof that which is appropriate to the present situation is when they apply themselves to each other, by their alternate facets, and poles to equators, that is, by their most dissimilar parts. This done, they construct a molecule of remarkable morphological properties, which in point of general form may be compared to a coupling joint or wheel with a broad tyre in mechanics, or to a blood-disk, or a life-buoy (see fig.).

Oxygen ∞.

The transformed structure of three atoms of aq, united or standing upon each other on the same axis, will now give a new structure, of which the central atom of aq alone is the same as before, and of which some idea is given by the following diagram, which may be regarded as representing the ultimate resultants of the elemental forces which constitute matter.

HO



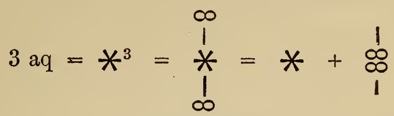
3aq = OHaqHO = 3HO

Using common types as proposed, we obtain the equation—

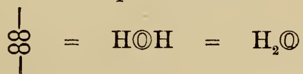
$$\begin{matrix} ✱ \\ ✱ \\ ✱ \end{matrix} \quad = \quad \begin{matrix} \infty \\ | \\ ✱ \\ | \\ \infty \end{matrix} \quad \text{or} \quad \begin{matrix} \infty \\ ✱ \\ \infty \end{matrix}$$

the atoms of H in HO on the formula on the right hand being supposed to be concealed between ∞ and ✱.

Now, this new form of 3aq, as well as 3aq itself, is obviously capable of decomposition, though not so easily as 3aq. The two atoms of |∞, each a transformed atom of aq, are capable together of forming a symmetrical, and therefore a separately insulable molecule. And thus we may have as the equation of partial decomposition of the above—



Moreover, the last, which is a coupled atom of transformed aq, may also obviously be decomposed. Using a double-faced letter ◎ as meaning a couple of atoms of O in union, to stand for the central structure ∞∞, we thus obtain the further equation—



And now let us ask, Is there any molecule known in nature or the laboratory which this ◎ of ours may represent? We can already compare it with aq and H. Perhaps they may explain each other. Now this they do in certain important features. Thus, as to the nunber of material elements or units of atomic weight which go to constitute H and ◎ respectively, the following facts appear. In H there are 5, and in ◎ there are $2 \times 5 \times 8 = 80$, or, calling the atomic weight of $H = 1$, that of ◎ = 16. In atomic weight then our structure which ◎ stands or agrees with an unit volume of oxygen as compared with hydrogen gas.

And since the law of assimilation leads us to expect that the unit volumes of individualised molecules, when in the same state, will be equal to one another, the product of the decomposition of any measure, say two volumes of aq, will give the same measure, say two volumes of H, and half the same measure, say one volume of ◎. Now this is well known to be the fact when common vapour is decomposed into hydrogen and oxygen gases.

As to the corresponding weight of the smallest unit-volume of aq when in the aeriform state, since it is equal to HO, it must be $5 + 40 = 45$, when $H = 5$ and ◎ = 80, *i.e.*, 9 when $H = 1$. Now this is precisely that of common vapour, its unit volume under the law of assimilation being held to be the same as that of H and ◎. And not only do these deductions explain the known phenomena of chemistry, but they bring along with them great relief to that science from great embarrassments. During the earlier period of the

◎ = O_2
Oxygen Gas.

atomic theory, the atomic weight of oxygen was generally taken at 8 when H = 1. It is now generally taken at 16. Meanwhile the phenomena of ozone have come in to make the darkness more visible. Now ozone, in all its features, especially in its characteristic, namely, its more intense chemical activity, is fully explained by the view here advanced; for, as the attainment of the spherical is the attainment of the aim of molecular action, it is the condition of molecular repose or inactivity, whence a single atom of O, being much more defective as to sphericity than a coupled atom, that is, than an atom of ◎, must be much more active. Not that any of the ozones (for there are more than one of them) consists of oxygen in single atoms, but they are all molecular structures of oxygen in which there is an odd atom of oxygen, which is on the eve of going off as a single atom on any change of action. Thus one of the best defined ozones is that whose sp. gr. is $1\frac{1}{2}$ times that of oxygen gas, indicating that the aeriform unit is that which is normal to sulphur when it assumes the aeriform state, that is, consists of three atoms of O, giving the equation—

$$O^3 = \text{◎}\,O,$$

speedily resolving itself into oxygen gas and active oxygen. (But for a more dense ozone, see Part II. p. 93, note.)

That oxygen in every case, ◎ as well as O, must be very active, follows from its extreme defectiveness in reference to the sphere. And that that activity must manifest itself chiefly by a generally parasitic or corrosive habit, follows from the fact that it is in polar matter that it is deficient. Hence, it will tend to squat down upon and adhere to almost every other body, for it can scarcely be so ill anyhow as when existing alone.

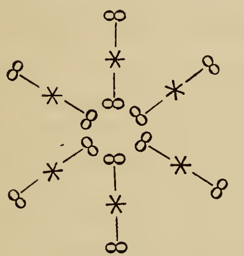
The morphological relation of O to H is also such, they are so entirely dissimilar, that when they are brought within the sphere of each other's attraction, they must rush together with immense force, the positive axis of the atom of H in the direction of the negative axis of the atom of O, piercing O, and causing such heat as must tend to explode it, the explosion being prevented, however, by the suitableness of the atom of H to take its place along with the 5 atoms of ♅, which constitute O in constructing an atom of aq, towards the regeneration of which the whole action tends, inasmuch as it tends to bring all the axes of the six nearly isomorphous members of H♅^{5} into parallelism, and into the same plane; for such is the condition of the six members in the beautiful structure of aq.

But, referring to the former parts of this work for evidence showing how completely our molecular structure of H and O and aq explain all the known phenomena of hydrogen, oxygen, and the aqueous element, let us here remark, what now appears, that our Beroe-like AQ (see fig. p. 144) is capable of a remarkable transformation. In fact, every three atoms of aq that enter into it may resolve themselves into the beautiful structure, of which the lines of the resultant forces are given in the diagram (p. 148), as has been already shown. Now here, both poles being atoms of oxygen, they are pentagonal, and not trigonal, like those of H and Ḫ. They cannot, therefore, run together into hexagons, and thereafter tend to form filaments and membranes only, and if spherules, then spherules still very open, though with no fewer than 36 atoms of aq in each. They are now altogether suited for forming a regular polyhedron, one of the Platonic bodies, the dodecahedron, namely, consisting of 12 members. Now in each of these members there are 3 aq. One molecule of AQ, therefore, gives precisely one such dodecatom :—

$$aq^{36} = AQ = (OHaqHO)^{12}.$$

To represent this beautiful structure in detail must be left to hereafter, when there will be students of these matters who can afford to lose, or have skill and a mind to make money by science. Meantime, with common types, it may be half shown as if it were in profile ; thus—

AQ =



$= aq^{36} = 36HO = 18H_2\text{Ⓞ}$

Thus our first complete differentiated structure in our primal or true protoplasm is capable of a remarkable transformation. Formerly, as AQ, being once free, it was capable of maintaining its freedom by the great heat and repulsiveness which must ever tend to actuate its whole surface. It was also capable of changing its form from prolate or lengthened to oblate or discoid, with spherical lying between. Now it must remain always spherical. And this may be remarked respecting it, that, being already wholly mailed in oxygen, both outside and inside, it is protected from the further attacks of this, the great terraqueous corroder. But it has at the same time, and in virtue of the same structure, become parasitic or adhesive on all sides. Such dodecatoms will, therefore, no longer remain free. They will tend to unite, though not with each other directly perhaps, yet with other matter. And thus they will induce, as we shall presently see, a further differentiation of our elemental protoplasm.

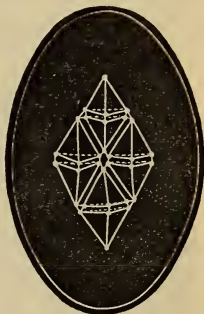
But have we not in this $(OHaqHO)^{12}$, as compared with the same matter as AQ, a preluding of the hybernating, or encysted, or ovulated state of organisms? And if it would not do to say that our aqueous spherule is an animated thing, can we fairly say that it is altogether dead? For my own part, I never can look at a stream of water rushing down from the mountain, or a river making for the sea, or a cloud forming in the air, without feeling that language is misapplied when the liquid element is spoken of as altogether dead.

But to pass from words to things, it may be remarked that, according to these views of the nature of the aqueous element, a most remarkable fact appears in its pathology. And that this must have important bearings in pathology, commonly so called, and therefore possibly in therapeutics, cannot but be, since our fleshy parts consist of aqueous matter to the extent of not less than three-fourths of the whole, and our brain of a still larger proportion. I allude to the great difference in capacity for heat between AQ and $(OHaqHO)^{12}$. The former, in fact, is more suitably constructed for entertaining a great amount of that vibratory or pulsatory action wherein heat consists, than any other molecular structure whatever. All the polar elements in every atom of aq that goes to construct it are free to pulsate without interference. In the latter it is quite otherwise. The same polar elements are to a great extent bound up. The capacity of the atom of O also (of which there are no fewer than 24 in the dodecatomic molecule) is very small compared with that of aq. When both are at the same temperature, therefore, that is, when there is an equilibrium of calorific action and reaction between them, according to their respective capacities, as structures composed of perfectly elastic elements, the quantity of developed action in AQ must be very great compared with what it is in $(OHaqHO)^{12}$. Aqueous matter, therefore, in passing from the former state to the latter must give out a great deal of heat, and so cause a hot fit in the organism in which the transformation takes place. When undergoing the contrary change, it must cause a cold fit, and that in both cases, all independently of the chemical union of carbon or hydrogen with oxygen, to which alone the phenomena of heat in the organic system is popularly referred. No doubt, to this chemical source exclusively animal heat has been referred with such exactness of calculation as seemingly to leave no room for any other calorific or frigorific agency, and indeed nothing more to be desired. But all such calculations are so made as to be self-correcting as they proceed, their product being also a foregone conclusion. It is therefore not to be wondered that they throw no light on the phenomena of fever or any of those abnormal states of the system as to temperature, between which and the rate of nutrition or of respiration no connection can be discovered.

And here let us bring to a close our inquiry as to the molecular structures which result from 5♅ when they can secure one atom of H first as a leader and then as a companion. Having hydrogen previously given, we obtain in this case aqueous matter and oxygen. But as has been already hinted, 5♅ may give being to other elements.

Sulphur.

In constituting an atom of oxygen, the 5♅ (which ♅ I have sometimes called hylagen) are united poles to equators and by their facets. But they may also be united poles to equators (that is, by their dissimilar and therefore permanently cohesive parts) by their edges. In this case, from the same material as gives an atom of oxygen, another element is obtained, which may be regarded as an alternate form of that material, and which in its functioning must have singular analogies as well as differences with oxygen. Let us in the meantime designate it by the literal symbol S (see the fig.).



S.

We may also conceive its genesis in connection with our molecule of $(OHaqHO)^{12}$ or reduced water, though that is not the most natural connection. Thus, in this molecule, the 12 surface regions being atoms of oxygen whose poles are empty externally, and in want of an axis, it is to be expected, supposing the molecule to exist in the midst of protoplasm in which atoms of ♅ (hylagen) have been already developed, that each atom of O will attract one of ♅ into its empty pole to form an axis for it. But every such atom of hylagen thus placed presents four points for the attachment of others which are still unoccupied, three on its equator and one on its outstanding pole. These, therefore, will also tend to be taken possession of by other atoms of hylagen. Thus each of the twelve atoms of O will be a cup or receptacle for five atoms of ♅, three of them standing out like three stamens around the other two, which are in one line and form the axis of the structure like ovary and stigma in the same flower. And thus we might fancifully say, that one molecule of reduced or concreted water has come into flower, and shown that it belongs to the monocotyledonous class of vegetables—a remark which, as has been already hinted, is not altogether fanciful or devoid of scientific value, since, when we compare together the two great classes of flowering plants, it may be truly said that the monocotyledons are those in which the aqueous tissue preponderates as compared with the dicotyledons in which the carbonaceous tissue preponderates. But as in a flower the tips of the stamens, either mediately or immediately, sooner or later, apply themselves to the stigma, so here the 3♅, at first supposed to be spreading, must sooner or later place their axes parallel to those of the other two, so that their previously free poles fall upon the equator of the upper atom of Ħ in the axis, which when they have once done they must remain united; for there is thus generated at each of the six regions where the five atoms of Ħ are united together a triangle of force, and at the seventh region, namely, the centre of the structure, a coupled triangle of force. Now, such a combination of equal and similar forces is so stable that it cannot be decomposed, or otherwise be destroyed, except by being exploded.

Thus we obtain, in each of the twelve surface atoms of O in our dodecatom, twelve atoms of S, which, once constructed, must be very stable. Now, on comparing S with O, it will be seen that S is defective in equatorial matter, as O was found to be in polar matter. There are, in fact, in the equatorial region of S, three cavities wanting to be filled up, there being around that centre room for six, as in aq. Now, for filling up, three other atoms of S are very suitable; and if they come on so that a pole of each may gain the centre of the fourth atom of S, which thus becomes an axis to the system of four, the whole structure may be very stable. We thus obtain S̶ = S^4. (See fig.)

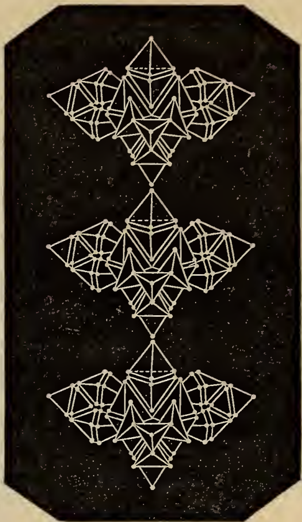
Sulphur, S^4 = S̶.

And now, our new element agrees with oxygen in being what may be naturally called a negative form, that is, a form which is defective in axial as compared with its equatorial expansion, and which, when viewed overhead in its æthereal atmosphere, is an oblate spheroid; the prolate spheroid being taken for the positive form.

Atoms of S̶, therefore (supposing that no very high temperature has imparted so much action to the axis as to improve their sphericity), when admitted to the aeriform state, will not rise singly, nor yet will they rise like atoms of ordinary oxygen in couples, but rather like oxygen as ozone in sets of three, one on each pole of the central atom —which last in such a situation will dilate so as to make the whole structure much more nearly spherical than it is represented in the diagram on the next page.

In this way then, the twelve atoms of S, which we have supposed to encrust one molecule of concreted moisture, may be imagined to escape from it.

As to the weight of this new aeriform (S^{12} = S̶S̶S̶) it must (if the law of assimilation still insists upon the normal or atmospherical unit volume for it) be six times that of oxygen gas. Thus, while the atomic weights of O and S are the same, namely, that of 5H = 5 × 8 = 40, that of Ⓞ = 2 O is 80 = 16 when H = 1, but that of 𝕾 = 4S is = 4 × 40 = 160 = 32 when H = 1, whence that of 3𝕾 must be 3 × 32 = 96 = 6 × 16, that is, six times that of oxygen gas. But when the pulsatory action or heat of the triple system of atoms of 𝕾 is so great as to separate them, and each occupies an unit volume, the weight of the aeriform in that case will plainly be twice that of oxygen gas. Here, then, we have all the well-known phenomena, of sulphur vapour as it rises, and when it is risen and very hot.



Sulphur Vapour, $S^4S^4S^4$ = $𝕾^3$.

Plainly, however, in 𝕾𝕾𝕾 the poles are overloaded. The proper element for carrying up an atom of 𝕾 into the aeriform state is not another atom of 𝕾 on each pole, but an atom of H on each pole. This gives a very beautiful, but also a very formidable structure, resembling a combination of lance and halbert. That it answers to the chemical formula H_2S when S = 32 is too obvious to require proof. But what a mistake in the popular chemistry to maintain that, because of the resemblance between the formulæ H_2O and H_2S, the substances which these formulæ stand for are similar! On the contrary, are they not as dissimilar as moisture, the most genial and the most necessary of all things to life, is from sulphuretted hydrogen, the most hateful and poisonous.

Sulphuretted Hydrogen, HS^4H.

When there is neither hydrogen nor heat enough to retain atoms of 𝕾 in the aeriform state, they must form into molecules. And since all the dimensions, both of S and 𝕾, are trigonal both as to poles and equator, the molecule must be that which results from trigonal constituents, which, when most perfect, is the icosahedron or icosatom.

And here we find a verification of the conclusion to which the law of assimilation conducts us, namely, that the volumes of molecules when in the dense state, whether liquid or solid, ought to be equal, or in some most simple ratio to one another. This, chemists have long ago found with regard to aeriforms. But having no certain principles to guide them with respect to the molecules of aeriforms when condensed, they have not attempted to calculate their specific gravities, except by creating a doctrine of the atomic volume of the elements in the dense state by the aid of the balance which, after all, loads the subject with exceptions and anomalies.

But a regard to the cosmical law of assimilation enables us to extend the method, known to hold good with regard to aeriforms, to liquids and solids also; and this we may show in the present instance. Thus, taking AQ as the unit volume for dense molecules, since its power as a type of volume, or as an assimilative agent in respect of volume, must be no less in our planet than common vapour azote and oxygen gas for aeriforms, we obtain the following formula for the specific gravity of sulphur:—

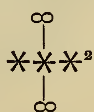
$$\frac{(\not{S})^{20}}{AQ} = \frac{20 \times 160}{36 \times 45} = 1{\cdot}96 \text{ Expt. } 1{\cdot}98.$$

But the icosatom of sulphur may be constructed in either of two ways, giving a small variation in the volume. Our $\not{S}$ must be also capable of a plastic state, interposed between two states of fluidity. It must also possess two forms of crystallisation; for a more ample notice of all which I must refer to previous parts of this work, as also for details respecting the various forms and properties of the fumes of burning sulphur, which in certain conditions of existence readily give up some of the oxygen in them, and in certain other conditions urgently demand more oxygen, being, in fact, represented by either of these formulæ—

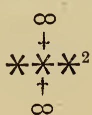
$$\not{S}\mathbb{O}^2, \quad S\mathbb{O}S, \quad SO,$$

in all of which the ratios of O and S are the same, and, as it happens, the weights of both elements equal (see Part III. p. 34).

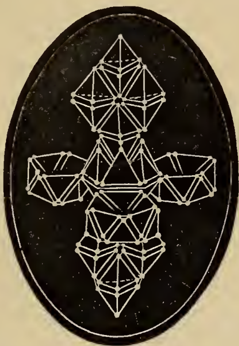
Rather let me here notice the form of repose to which this element attains when aqueous matter is supplied to it. We have seen that the primal aqueous structure which we may call

Moisture, =  = $OH\overset{4}{a}qHO = 6aq = 6HO.$

Now, instead of this, when fumes of S are flying about, we may have the structure still preserved, while S is substituting H, thus giving—



in which the dagger represents one atom of S. Here we have fumes of sulphur in a moist or hydrated state, the poles, however, being over-headed with oxygen. Now let another atom of O be supplied, and then the oxygen will be transferred from the poles to the equator; for the three atoms of S may be symmetrically applied there in the place of the three atoms of aq. In this way a much more stable structure must result than existed before, while yet the original type is still preserved. Now, what have we here? It is what we call sulphic acid, otherwise

Pure Oil of Vitriol,  $= Sa\overset{\cdots}{q}S = SO_4H$.

We may represent its formula by $Sa\overset{\cdots}{q}S$, in which the dots stand for atoms of oxygen. Its usual chemical formulæ are $SO_3.HO$ and SH_2O_4, in the latter S = 32 and O = 16. This latter, however, though at present it is the favourite, gives chemists much trouble in consequence of the ascertained specific gravity of oil of vitriol. According to that formula, and the chemical rule for the specific gravities of compound vapours, its sp. gr. ought to have been the double of what it is actually found to be. It ought to have been 3·2 +, instead of which it is only found to be 1·6 +. Hence it is necessary to admit that the aerial unit of oil of vitriol occupies 4 normal or hydrogen volumes instead of 2, which it is destructive of the present state of chemical hypothesis to admit, except as an anomaly in nature (which is nonsense). From this predicament, however, our view of the structure of the atom of oil of vitriol relieves the afflicted vapour.

But more interesting still is the light which our molecular morphology throws in this case on the specific gravity of oil of vitriol in the dense state. Thus, suppose the boiling of oil of vitriol to have been continued so long that no more water can be expelled, it is still found that $\frac{1}{12}$th of an atom of water remains for every atom of oil of vitriol. Now let atoms of oil of vitriol gather round an atom of aq as a nucleus, when all the rest of the original aq has been expelled as by boiling, then since there are 12 points in the atom of aq, on each of which an atom of pure oil of vitriol may fix itself, we shall have for every atom of oil of vitriol just $\frac{1}{12}$th of an atom of water remaining, a result which has been found in the laboratory, nay, found impossible to prevent—though it is surely very strange, when viewed in the light of the popular chemistry, that it should be so,—but not the less to be cherished, perhaps,—since wonder is one of the chemist's most favourite emotions. As to the sp. gr. of the liquid, which it is more agreeable to us to be able to deduce than to wonder at, its equation stands thus—

Strongest Oil of Vitriol attainable by boiling, $\frac{(Saq\dddot{S})^{12}+aq}{AQ} = \frac{(12 \times 245)+45}{36 \times 45} = 1{\cdot}843$ Expt. 1·843,

which corresponds to a temperature exactly the same as that at which the sp. gr. of sulphuric acid was taken by Professor T. Thomson in Glasgow, that great centre of the manufacture and use of oil of vitriol, that great chemist always reasoning well, though not always weighing so accurately.

A more natural structure is when atoms of oil of vitriol gather round an atom of AQ, which gives 2aq in each atom of oil of vitriol, or when, at any rate, there is an atom of aq for every atom of S. This is known as the glacial acid. Aggregated around the sulphic pole, the molecule has stability sufficient to stand the boiling. As that pole is trigonal, the perfect molecule must, therefore, be the icosatom. Allowing to so large a molecule two aqueous volumes, we obtain as its equation of sp. gravity—

Glacial Oil of Vitriol, $\frac{(aqSaq\dddot{S})^{20}}{2AQ} = \frac{20(45+245)}{2 \times 1620} = 1{\cdot}79$ Expt. 178,

which is again, as we may say, quite exact, since the second decimal depends on the temperature at which the experiment is made.

The molecule of the glacial acid, however, though not in the laboratory, yet in nature maintains the more perfect aquæform, and consists of 36 instead of 20 members, at least when its acidity has been quenched or neutralised by an encrustation all over of lime. This is proved by the sp. gr. of sulphate of lime, gypsum, or selenite (see Part II. p. 95, or Part III. p. 41.)

But let us here pass on, remarking only that, from these discoveries, it appears that the views of chemists are too narrow when they regard hydrogen alone as the acidifying principle. From these discoveries as to the structure of the atom of sulphuric or rather sulphic acid it appears that Ħ as well as H, when it forms a pole, as in the atom of S, or sulph, can acidify. Both are indeed isomorphous, and that they should both be acid-producers favours the idea of the old chemists, that there must be something lance-shaped about an acid since it is lancinating to the tongue, and generally of a piercing and solvent nature.

Ammonia.

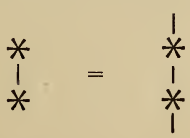
The first differentiation of our protoplasm we have found to be the construction in it of atoms of $\underset{o}{H}$ and H, which enter into union with each other, so that H is saturated with $\underset{o}{H}$, whence, taken in its limits of maximum and minimum expansion, we obtain the equation of—

Exploded Steam, = $H\underset{o}{H}^5$ = aq = Common Vapour.

Let us now again recur to an atom of H as a nucleus, and on each of its 5 points for union, instead of an atom of $\underset{o}{H}$ let us place an atom of their united product aq, giving—

Haq^5.

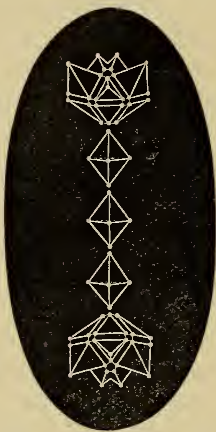
This structure resembles that which we found to be the first type in the progressive synthesis of atoms of aq into molecules (fig. p. 147). It differs only in this, that the central body, instead of being an atom of aq, is an atom of H. Consequently there are in the axis, instead of 3 aq, only 2 aq, and these two bolted together, as we may say, by an atom of H, its trigonal or lance-shaped positive poles piercing into and filling up the negative or hollow poles of the atoms of aq above and below. Now, this difference of structure must introduce a great difference of product as to secular results. In fact, the two atoms of aq, thus bolted together by the atom of H, cannot easily separate. The whole must usually continue as one structure. But if so, then if there be any defect of symmetry in its structure, it must secularly undergo improvement in that respect. Its symmetry will be perfected as far as possible. Now, on inspecting the atom of aq, it will be seen that in its centre there are eleven material elements or unit-forces, while six are sufficient and proper for the symmetry of the hexatomic structure. There are five, therefore, which are disposable. The terminal polar regions of the coupled atoms of aq also are empty and negative, while an atom of H in each would fill them in a proper manner. Now 5 units are just the material required to construct an atom of H. They do, in fact, tend naturally to develop into an atom of H. Secularly, therefore, and very soon after aq has been given to nature, aqHaq will be given, and the latter will develope into HaqHaqH, the spiritus asper above the symbols of aq, as given below, implying that each has given out one atom of H—



aqHaq HaʿqHaʿqH

Now, when the equator of such a structure is loaded and expanded, as for instance, by carrying 3aq (which we have supposed) or otherwise, so that the whole structure, viewed overhead in its æthereal atmosphere, is oblate, then under the law of sphericity there must exist in the axis a force calling for the extension of that axis, and in that case the axis may be expected to extend by undergoing a most remarkable transformation. No more now, indeed, can the atoms of aq transform themselves, as before, into HO. Each of the five atoms of Ħ that now go to the aquæform aq has lost one of its material elements or forces in the centre. Each now consists of seven instead of eight elements, and is intensely unsymmetrical in the structure of its equator. The 5Ħ in aq must therefore remain united as they are, to supply each other's defect of symmetry. They cannot open and turn round as they might do, in order to construct an atom of O. They must keep together at the centre as they are. And when, by the lengthening of the axis, the atom of H is taken from the circle of 6 and placed in the axis, the five defective atoms of Ħ, when duly compacted, must give a hemiform such as ϶, and aqHaq will now give ϶H^3Є.

Zote ⍵.

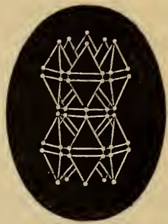


Ammonia (hydrozotic).

Azote ⦵.

Meantime, the atom of H in each of the poles of HaqHaqH will be given off during the transformation; for the poles of ϶ are 5-partite in structure and no longer conformable to the trigonal shape of H.

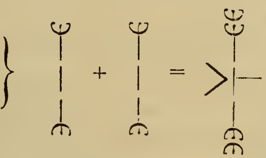
And, suppose the structure ϶H^3Є to be decomposed as by an electric shock or otherwise, plainly the two dissymmetrical hemiforms will under the law of symmetry and sphericity couple, for by so doing they may generate an eminently spherical and symmetrical element (see fig.). Now, since this coupled element possesses such a perfect form, it must be very reposing in nature, or, as the chemist says, inactive. And its atomic weight must be $2 \times 5 \times 7 = 70$, *i.e.*, 14 when $H = 1$. It therefore represents azote. And the dimorphous structure which we have obtained, when decomposed, must yield three volumes of hydrogen and one of azote. It therefore represents ammonia. In its primal form it is isamorphous with a couple of atoms of common vapour united on the same axis, and must, therefore, in its functions, have many analogies with common vapour. Its activities and powers, however, must be much greater. In fact, they are wonderfully many. Common vapour, and the aqueous element in general, is quick, but ammoniacal vapour is far quicker and of double force. Both are plainly most suitable for entering into the construction of tissues which are to possess quickness or animation, but ammonia still more than aqueous matter.



Ammonia (aquæform).

But ammonia may lose its quickness and become stable by doubling, and this is the state to which the chemist most frequently reduces it in the laboratory. Thus, making use of the pharmaceutical symbol to stand for half azote (which, from its extreme activity attaching to its hemiform and want of symmetry, we have called zote), we shall have, when all lateral or equatorial support has been taken away—

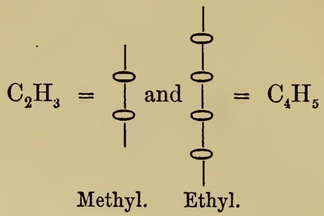
2. Atoms of Zotic Ammonia = NH_3 of chemists.



1. Atom of Bizotic Ammonia = N_2H_6

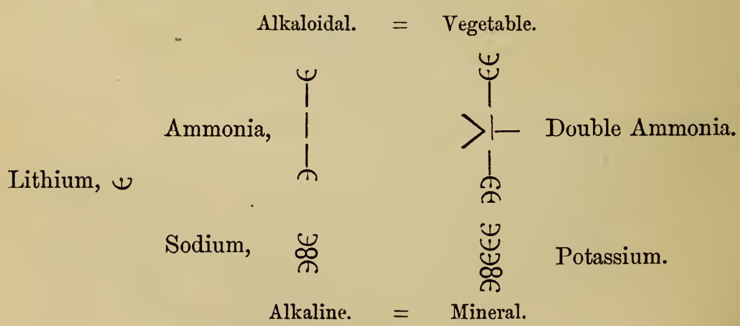
The latter is no longer capable of lapsing into the aquæform. It may also be stable to a considerable degree, for though its body be still volatile hydrogen, yet that hydrogen exists in normal typical molecules, each being HH^5 homologous with H℔^{5} and Haq^5, and, indeed, a repetition of the form of the single atom of H, though with five joints or articulations. In fact, HH_5 or HH^4H is the typical aeriform molecule of this, the lighest of the elements.

Here we may remark, in passing, the extent to which chemists have amused themselves in substituting for the simple hydrogens which are in natural ammonia, other hydrogens which are less mobile and volatile, inasmuch as carbon or some other fixed element enters into their structure, while yet both their equators and poles continue to be atoms of hydrogen, so that they may function like single atoms of hydrogen. Adopting in the meantime a cypher as the printers' type, to stand for an atom of carbon, its atomic weight taken at 6 when $H = 1$, as it used to be universally (and for good reasons, as will appear). Such hydro-carbons are (alcohol radicals !)



&c., their insulable forms being usually their doubles with carbon poles.

When the true ammoniacal structure is thus steadied by C_2H_3 or C_4H_5, &c., instead of H_3 or H_6 (thereby destroyed for all the uses of life), and oxygen is made to enter into the structure, chemists are surprised to observe how similarly to potass and the fixed alkalis the products function. But the truth is, that in these structures of the laboratory, inasmuch as the volatility of pure hydrogen in ammonia is overcome by the addition or substitution of more stable elements, there is an approach to the constrution of the fixed alkalis. The latter we obtain, when for the 3H or 6H in the atom of single or double ammonia, oxygen is substituted as the coupling joint for the single or doubled atoms of zote which constitute the polar bodies. It is true, that in this case the zotic element has usually quite a different genesis from that which results from the transformation of ammonia, and more generally possesses the full atomic weight of 5H = 40 = 8 when H = 1 instead of 7. Still its reduction has been fully accounted for (Part III. p. 52); and when thus reduced, it has been shown to explain all the properties of lithium. Thus, contenting ourselves with the types instead of diagrams, we have—



Their molecules are all the usually differentiated dodecatom, so that their sp. gr. may be deduced, allowing $\frac{1}{2}$, 1, and 2 normal volumes as they increase in complication—thus

$$\text{Lithium, } G \ldots \frac{(L)^{1+12+1}}{\frac{1}{2}AQ} = \cdot 60 \text{ Exp. } \cdot 59.$$

$$\text{Sodium, } G \ldots \frac{(Na)^{1+12+1}}{AQ} = \cdot 99 \text{ Exp. } \cdot 97.$$

$$\text{Potassium, } G \ldots \frac{(K)^{1+12+1}}{2AQ} = \cdot 84 \text{ Exp. } \cdot 86.$$

$$\text{Ammonia, } G \ldots \frac{(Am)^{1+12+1}}{AQ \text{ or } 2AQ} = \cdot 73 \text{ Exp. } \cdot 74.$$

CARBON.

But what of carbon, whose atomic weight, contrary to the present fashion I am giving, as 6 when H = 1, while it is now usually given at 12, and that for reasons which, if applied to our vision generally, would prove (since the functioning of both eyes is single), if only our eyes were so small as to be invisible, that we were all monoculi.

As to carbon, then, it may be remarked that, wherever zote has been constructed, another element is imminent. Let the 5 units which render one polar region of the atom of zote, 5-partite and dissimilar to the other polar region, be constructed into an atom of H, as they must secularly tend to be, and then instead of the original 5Ħ, we obtain a beautiful cellular structure of exquisite symmetry and stability, carrying an atom of H on its pole. Like O and ◡, it is oblate, however, and therefore when free its atoms will tend to go in couples also.

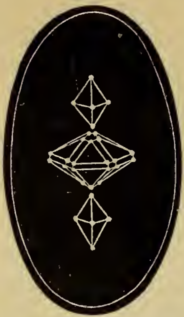
CH.

Carbon ⬭

Its atomic weight is 5Ħ − 2H = (5 × 8) − 2 × 5 = 30, *i.e.*, 6 when H = 1, and that of the coupled atom corresponding to the unit of oxygen-gas or azote is 12. In a word, in every feature this highly reduced element represents carbon.

Its characteristic is that, in order to reach it, two atoms of hydrogen must be developed out of the matter, viz. 5Ħ, which furnishes it, so that, previous to loss, it must appear in nature in union with two atoms of hydrogen, one on each pole (see fig. HCH, next page).

But such a form is very prolate, while two by coupling reproduce the primal type of an atom of H as nucleus, with 5 other atoms around it, in this case 3 atoms of H for the 3 points for union on the equator



Nascent Marsh-gas, HCH.

Marsh-gas, $C\overset{4}{H}C = C_2\ H_4$.

of the nuclear atom, and one of carbon on each of its poles (see fig. $C\overset{4}{H}C$). And, in reference to such a molecular structure, whether we look to sphericity, cellularity, or adequate differentiation, we see that it is very perfect. Now to us it plainly represents marsh-gas; and therefore prepares us for finding that substance so generally diffused, and such a survivor in nature as it actually is.

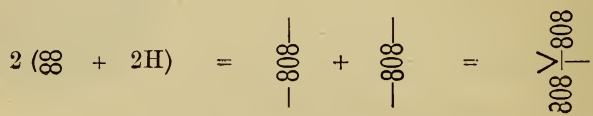
Do not the conditions of its genesis also explain why carbon should be the very substance that it is, so averse to, and even incapable of, the aeriform state? Thus every atom, when its genesis is complete, *i.e.*, as HCH is furnished with two atoms of hydrogen, which we may regard as two wings. And when they have been cut off or carried away, is it wonderful that the bare atom of carbon remaining should be as incapable of flight as it is found to be?

At any rate, it appears that it is to this, its aversion to the aeriform state, and its determination to redintegrate its original union with hydrogen, that carbon owes its peculiar value in the economy both of animal and vegetable nature. Meantime its value as a fixed element is great.

Thus we have seen that both the aqueous and the ammoniacal elements, which are the first products of the differentiation of our pure or homogeneous protoplasm, are both of them very quick to go off in vapour, or, if remaining, are ready to be transformed into still more aeriform elements, namely, into hydrogen, oxygen, and azote. Life in an organism, therefore, if that organism were constructed only of them, could not but be altogether ephemeral. Plainly, there is wanted some other kind of element which in its nature is fixed, or such that it shall not tend to go off as an aeriform—not altogether fixed, for that would imply a state of death, but fixed in a degree so as to moderate more or less the tendency of the others to go off into the aeriform state. Now for such a function carbon is altogether suited. Every atom of it may indeed be regarded as a bolt, sure as adamant, which indeed it is. Keep away oxygen or hydrogen and it will remain fixed and a fixer long enough. But let oxygen gas come in the way, every atom of which is precisely adapted for nipping up an atom of carbon and carrying it off as an aeriform, and off goes the carbon. Thus, when two atoms of oxygen exist, coupled on the same axis, thus constituting an unit of oxygen gas, there is, in consequence of the concavity of both the interior poles, a hollow in the centre, or an empty stomach. Now this hollow is precisely a mould for an atom of carbon! Hence an atom of oxygen gas (which is everywhere prevalent in the terraqueous globe), when it enters an organism in the active, empty, hungry state, and meets with an atom of free carbon, forthwith devours it, and though to all outward appearance still only an atom of oxygen gas, isomorphous and isovoluminous, and able to escape by the same channels, or channels no larger than those by which it entered the organism, it carries off the carbon. But though isovoluminous with the pure oxygen, it is now all the heavier by the atom of carbon which fills the stomach of each aeriform element. It is also, as might be expected, less elastic and less diffusive. Hence it tends to prevail in the lower strata of the atmosphere, where there exists the vegetable kingdom. And for this kingdom it supplies the requisite food!

Carbonic Acid, 808 = CO_2.

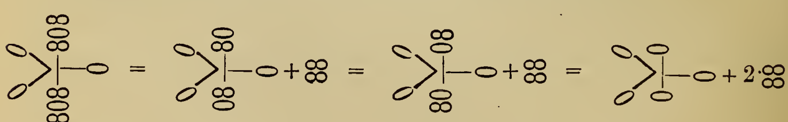
And here the deeply interesting question in physiology occurs, How comes it to pass that, while in the most highly animated organisms, those of animals, namely, oxygen gas lays hold of carbon and bears it away in such firm union that even the chemist can scarcely decompose it; yet in stable and cool organisms, those of plants, this carbonic gas is readily decomposed, the oxygen gas escaping pure and free again, while the carbon is retained to perform the same function in vegetable nature (that of imparting durability to the tissue) which it had previously performed in animals? To this the answer, I believe, is, that inasmuch as the primal union of carbon, even the union implied in its genesis, was with hydrodgen, not oxygen, so, under the law of assimilation, acting in reference to time, that is, as a law of heredity or redintegration, the hydrogen nascent in the vegetable tissue succeeds in expelling the oxygen from the carbonic gas which is brought in, appropriating the carbon, and setting the oxygen free. If it be alleged that such a view is a substitution of magic for science, the answer is, that that is just as one takes it. The operation of all law may be said to be magic till the mechanism is discovered by which the law is realised or worked out. Moreover, here we are not without an apprehension of the mechanism. Thus there is nothing better established in molecular science than that it is dissimilars which tend to unite, while similars tend to repel each other. Now, by similars in our molecular morphology we must, in the first place, mean similar forms—forms which, viewed overhead in their aetherial atmospheres, are either both or all oblate, both or all prolate, both or all spherical. Thus an atom of oxygen viewed overhead is oblate, so is a tetratom of hydrogen, (see the diagram below, and that of marsh-gas, fig. $C\overset{4}{H}C$, p. 164). Let us suppose, then, that two atoms of carbonic acid gas, CO_2, have entered into the vegetable tissue where chlorophyll is normally functioning. Then, in order to their being wholly redintegrated, it is necessary that an atom of H be supplied to each of the two poles of both, for this is necessary to redintegrate the primæval 2 aq, from which we suppose everything organic to have been derived. But when the poles are thus supplied, the two are ready for doubling into one—



There is thus constructed as the equatorial body in the unified structure a tetratom of hydrogen, which is very oblate.

Tetratom of Hydrogen.

But in maturely elaborated parts of plants, in chlorophyll, for instance, there is so much carbon, compared with hydrogen, that we cannot suppose that the outstanding poles of the three atoms of hydrogen in the equator of $C_2H_4O_4$ would long remain naked. Doubtless each of them, if not from the first, would soon be capped by an atom of carbon, and become an atom of hydro-carbon, CH. Now, by such an addition the equator would be still further extended, and thus the whole form rendered still more oblate. But if so, it will be rendered still more highly repulsive of the oblate oxygens on the poles. We may, therefore, when the structure is rendered active, as by the sunbeam playing upon it, expect a process of dissociation and reduction, which may be thus conceived—



$C_3H_42CO_2$ = C_3H_42CO + ◎ = C_5H_4 + 2◎

Thus we obtain, as the product of the solar action, pure oxygen gas and a hydro-carbon. Now, let us see what this hydro-carbon represents. Its elemental formula is C_5H_4. But it is obvious that it is highly polymorphous, for the three atoms of carbon may apply themselves to the three equatorial hydrogens and to the axis in a great variety of ways. If, then, this hydro-carbon represent anything in vegetable nature, we may expect a considerable number and variety of hydro-carbons with the same chemical formula. But will the single element C_5H_4 be insulable by itself? No, its form is so oblate that, like so many other molecules that we have met with when in the aeriform or most fully individualised state, they will still go in couples on the same axis, each represented by the formula $C_{10}H_8$. Now, this is the half-formula of what is usually given as that of the non-oxygenated essential oils. Its sp. gr., as compared with air, must be—

The Vapour, $G = \frac{C_{10}H_8}{\frac{1}{5}(4Az + ◎)} = \frac{300+40}{\frac{1}{5}(360)} = 4 \cdot 7$—Expt. 4·7. Essential Oils.

As to its condensed state, since its trigonal equator extends so far beyond its poles, its molecules must be those of the trigonal series, that is, the tetratom or the octatom, and ultimately the icosatom, as the culmination molecule. Now, constructing these possible molecules, and allowing half a normal volume to the tetratom, one normal volume to the octatom, and two to the icosatom, we obtain, just as in the distillation of the essential oils, a lighter and less perfect (and consequently a more volatile and fragrant oil), and a heavier and more perfect (and consequently less valuable perfume), the specific gravities of both, as determined by the balance, being the same as those which our formula gives—

Light Essential Oil, $G = \frac{(C_5H_4)^4}{\frac{1}{2}AQ} = \frac{4(150+20)}{\frac{1}{2} \times 1620} = \cdot 84$ Expt. ·85.

Heavy Essential Oil, $G = \frac{(C_5H_4)^{20}}{2AQ} = \frac{20(150+20)}{.2 \times 1620} = 1 \cdot 05$ Expt. 1·04.

The economy of nature then, in relation to oxygen and carbon, so far as we have touched upon it, is this, that, by their respective forms which imply their eager union wherever oxygen can penetrate among atoms ot carbon existing single and free or loosely engaged, they unite all through the animal organism, which is everywhere penetrated by oxygen, and everywhere disengaging carbon in single atoms. By this means the effete carbon in the animal organism, which is tending to a chaotic and wholly obstructive state, is constructed along with the oxygen now taken in union with it into carbonic dioxide, commonly, but not correctly, called carbonic acid,* a most serviceable heat being generated.

* On Carbonic Acid, properly so called. see P. III. p. 92.

Thereafter, the true carbonic acid formed, when it has served important purposes in the organism, breaks up into carbonic acid gas, which escapes into the air by the lungs, the skin, &c. Thus, the organism is relieved of matter which must otherwise soon have proved fatal to its action, and have caused death. But having thus gained the atmosphere and the sunshine, this deadly gas brought by its own weight into contact with the ground and its vegetable covering is decomposed there, its oxygen being restored in purity to the atmosphere, to serve for breath and life again to the animal kingdom, while its carbon goes to supply just the food which is needed by the vegetable kingdom in order to the construction of its timber, which is so necessary in the processes of human art, as also to the birth of those perfumes by which that kingdom in its most sunny and highly matured parts is rendered so deliciously fragrant.

Thus, in pursuing the differentiation of our primal homogeneous protoplasm, we have obtained, first, aqueous matter, as common vapour; and, secondly, from it, by doubling and reduction, ammoniacal vapour. Then, by the decomposition of aqueous matter, we obtained hydrogen and oxygen, while to the same epoch of nature the appearance of sulphur belongs, and soon after the fixed alkalis and silica, of which, however, nothing has been said here.

Azote.

By the decomposition of ammonia we have obtained, instead of oxygen, another still more active element—an element so active as to be like fluorine, still unknown to the chemist in a separate state. This we have called zote. And as oxygens by coupling give oxygen gas, which is much less active than oxygen in single atoms, so do zotes by coupling give azotic gas, the other great constituent of the atmosphere, which is very inactive. (See fig. p. 160.)

Where atoms of zote cannot couple we have seen that, owing to their dissymmetry, they must suffer reduction. And in this way there is given to nature carbon in union with hydrogen. (See fig. p. 163).

Silicon.

Let us now remark, that the atoms of zote, when so coupled as to constitute an atom of azote, that is, when united so that the summets of their 5-fid poles merely touch each other, may also give to nature another element, which plays an important part in the simplest organisms as well as in the crust of the earth generally. Thus, instead of merely touching each other by their tips, let these 5-fid or 5-toothed regions of the two atoms of zote in one of azote be locked together by pressure or

Si.

otherwise, and in this case there must result an exquisitely spherical molecule with the same atomic weight as azote, and still more inactive or reposing. I have elsewhere shown in detail, and it may be easily seen that such a structure represents silicon.

Calcium.

But what of lime? Where it, may be asked, in our process of differentiation, does calcium make its appearance—calcium which plays such any important part both in the organic and the inorganic world?

To this it may be answered that given free hydrogen existing in quantities under cold or pressure or both, or on the pole of a molecule, such as sulphuretted hydrogen (see fig. $H_2\mathfrak{S}$, p. 155), our calcium may possibly be generated. Thus, let atoms of $H_2\mathfrak{S}$ form into molecules, then in virtue of their trigonal dimensions, these molecules must be icosatoms. Each nucleus will thus be a structure consisting of 20 atoms of hydrogen wedging each other together. And this they may do secularly so closely that the interceding æther of their atmospheres may be in the main extruded, and thus the group of 20H be consolidated so as thereafter to be undecomposable in the laboratory. Its form and structure are eminently fine. Its atomic weight is plainly $20 \times 5 = 100$, *i.e.* 20 when $H = 1$. It may be shown to represent the atom of calcium when it has attained its utmost perfection of structure, or what may be called organic calcium. Calcium, however, must also result from the dedoubling of an atom of unreduced potassium as has been explained elsewhere (Part III. p. 48).

Ca.

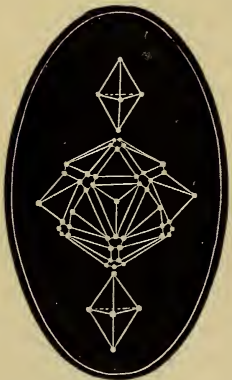
Silicium.

It has also been elsewhere shown that this calcium H^{20}, though it possess such an exquisite structure, yet being wholly undifferentiated cannot be altogether stable and permanent for ever in nature. It has been shown that the 20 material units in its centre must secularly repel each other until they take the place of those on the surface, which will meantime go off in groups of 5 as atoms of hydrogen, while also the 5 on the poles will gather themselves up into hydrogens. And thus, there will result a structure similar to that of nascent marsh-gas (see fig. SiH_2, next page), but with this difference, that the central molecule in this case has an atomic weight of 70, *i.e.* 14 when $H = 1$, and represents with great perfection all that is known or conceived of silicium.

This, the prevalent constituent of our planet, then, according to our molecular morphology, exists in two states—a less mature state, containing still 10 units in its centre, wholly metalloidal, which the term silicon very well expresses, and one which is truly cellular, and as has been shown elsewhere, might be called semi-metallic, being an element of a brittle metal, and which the name silicium equally well expresses.

Hence, a consequence of our theory of matter, to the effect that calcium, in the lapse of the ages, must be gradually transformed into silicium with emission of hydrogen (which will give a second crop of calcium, and, along with oxygen, aqueous matter, &c.).

But where oxygen gas abounds, as it does everywhere in the terraqueous globe, of course it is not hydrides, such as CH_2 and SiH_2, that we are to expect in nature. An atom of Ⓞ will attack each pole, and there will result $CO_2 + 2aq$ and $SiO_2 + 2aq$.



SiH_2

Silicic Acid, SiO_2

Since the poles of silica are pentagonal, its molecule must be the dodecatom, which may, of course, be either differentiated as usual or not. Both molecules occur in nature. But since coupled atoms of silica in the first instance, giving an atom of Ⓞ in the centre and an atom of O on each pole, possess a structure so much more perfect than the single atom, it seems likely that natural molecules of quartz will thus consist of coupled molecules. This gives—

$$\text{Quartz of Fusion, } G = \frac{(OSi\text{Ⓞ}SiO)^{12}}{AQ} = \frac{12 \times 300}{1620} = 2{\cdot}2 \text{ Exp. } 2{\cdot}2.$$

$$\text{Crystallised Quartz, } G = \frac{(OSi\text{Ⓞ}SiO)^{1+12+1}}{AQ} = \frac{14 \times 300}{1620} = 2{\cdot}59 \text{ Exp. } 2{\cdot}6.$$

Let it not be inferred from this that, along with all previous life, all traces of it even, are in the course of being obliterated, and merely silicates and silica destined to increase in quantity for ever. They possibly may do so to a vast extent. But let the ten units now on the outside of the equator of the atom of silica take the course of the poles, and be gathered up, as they must be, into an atom of hydrogen on each, while the ten triangles of forces thus left naked in the equatorial region take a similar course, joining these summits in the axis of the structure, then the atom of silica is by these axial movements transformed into two structures, each consisting of carbon, oxygen, and hydrogen. And a dodecatom of silica gives the following most remarkable result:—

$$\text{Silica,}\quad (SiO_2)^{12} = C_{24}H_{24}O_{24}\quad \text{Sugar.}$$

So that out of the most fixed or dead form by a simple normal movement of material elements, the most vernal product of life may possibly arise!

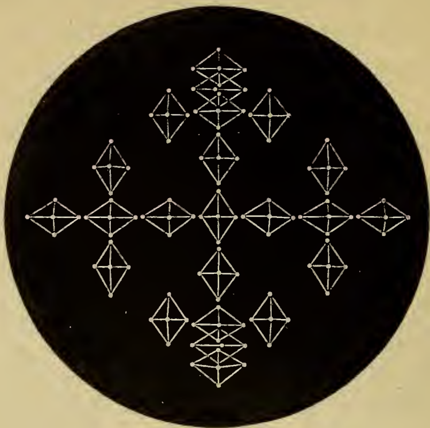
Phosphorus.

From $H\mathfrak{H}^5$ by the course of nature, as we conceive it, we have obtained aqueous matter, oxygen, sulphur, and ultimately lime.

From Haq^5, by the same course, we have obtained ammonia giving similarly azote and carbon and other elements.

But HH^5 may give rise to molecular structures as well as $H\mathfrak{H}^5$. And since both are isomorphous, we should expect from HH^5 a similar series, especially a light oxygen, a light sulphur, and a light carbon. But except the last named, which represents boron (considered as monotomic), it is no wonder that the existence of the others has not been verified by the terraqueous chemist. Our planet is too small and its synthetising forces are too weak to make much of such a light and volatile subject as hydrogen, when it is not kept down by such elements as are more weighty than ours, or a more intensely gravitating sphere. Nevertheless, we have seen HH^5 forming the body of the atom of double ammonia, and we have characterised it as the typical aeriform molecule of hydrogen, that in which the form of the single atom is reproduced on a large scale. And if now we construct a large aeriform molecule by five of these hexatomic hydrogens placed around, so as to saturate a single atom of hydrogen as a nucleus, it appears that, after the complete condensation of the atoms of light oxygen and light carbon (boron), developed during the process of secular transformation, there results a structure, which has been discovered by science, very generally diffused, though in small quantities, over the crust of our globe, and which has justly excited the greatest interest of the chemist and the physiologist.

The structure $H(HH_5)^5$, of which a diagram is given in part, so as not to confuse the eye (see next page), has for its atomic weight $5 + 5\ (5 \times 6) = 155$, that is 31 when $H = 1$. Now, this is the singular but well-known atomic weight of an atom of phosphorus. For a convincing development of this element, I must refer to Part III. p. 105, where it is given in company with its isomorphs, vanadium, arsenic antimony, and bismuth. I will only remark here, that in phosphorus molecular synthesis comes to a crisis. It may be viewed as constructed wholly out of hydrogen and boron. But reasons may be given why, under any force adequate to decompose an atom, it could not be resolved into these elements again. It looks rather as if, along with every atom



$5H^6 + H$ in the centre $= H^{31}$.

of hydrogen given (except, perhaps, those which would be developed out of the axis), there would also be given off matter in single units. Now, these single units, springing off into the medium of light, might be expected to impart to the residuary substance an eminent degree of luminosity or phosphoresence, unless this dissipation were prevented, and the genesis of hydrogen again secured by the catalytic action of hydrogen introduced into its ambient atmosphere. In a word, this structure bids fair to represent and explain all the specific characters of phosphorus. But having shown this with considerable detail already in the third part of this work, it need not be repeated here.

I may here remark, however, that the current belief that phosphorus contributes in a special manner to mental functioning, is based on no better evidence than that it is found in greater quantity in the brain than in any other of the soft parts. Perhaps it were nearer the truth to regard its presence there as an evidence of failure so far, in the intense analytico-synthetic action of that organ whose special function is to give birth to something lighter and more luminous still, and out of the sphere of the material altogether.

But phosphorus is intensely useful in nature, both from its dissimilarity equally to hydrogen and oxygen, and consequently its relative activity and the stability of its combination with oxygen when once constructed.

CHAPTER XVI.

ON THE ULTIMATE PRODUCTS OF ÆTHERIAL, MATERIAL, AND MOLECULAR ACTION.

In the Sketch of a Philosophy which these words now bring to a close, the economy of creation is not regarded as a theory of development all in one direction, as is commonly supposed, but as a cycle in which after development and as its fruit, the last term gives again the first.

Æther and matter after developing a molecular economy become the mother and nurse of beings, which enter into the world of spirits, and present themselves to the great Creator; nay, enter into communion with Him, so far as the finite can comprehend and unite with the Infinite, and partake of His everblessedness.

In the beginning is the Author of all. And as His most immediate creation there is the world of spirits, in the realm of light or the æther, which is their home, the expression in space of the cosmical law of assimilation to the Divine, creation in the æther aiming at His immensity and omnipresence. Thus in the cosmical law there is instituted a tendency to ultimate dissociation or analysis.

But under the same cosmical law, in virtue of the unity of the Creator, which is His indefeasible attribute no less than His immensity or omnipresence, there is awoke also in the realm of light, or the ætherial medium, a contrary tendency in the ætherial elements to association into groups or nebulous specks, in the centre of each of which, when it has attained a certain force, confluence of a definite number of ætherial elements takes place, constituting an atom of a different order from the ætherial element, and which, as the nucleus of its accompanying ætherial atmosphere, gives to nature the material element.

Under the same law and synthetic mode of action the material elements continue to aggregate into thousands of molecules (the far greater number of which are decomposable by chemists, though about sixty-three resist); and these molecules hold on aggregating still until they constitute organisms, whose mobility and easy decomposibility show that the analytic agency of nature is greatly modifying the synthetic, and gaining upon it in our planet.

In terraqueous organisms these contrasted but co-ordinated agencies culminate, the synthetic in muscularity, the analytic in cerebration.

A cerebral unit, viewed physically, is an organic aggregate, consisting of the lightest elements, held together in a very open structure; and, viewed physiologically, it may be regarded as an individualised volume of æther, more or less spherical, supported by a scaffolding of matter. It is therefore analogous to the nebulous speck in the celestial spaces to which, according to our philosophy, the material element owes its genesis out of the ætherial.

Here, then, we find the material economy assimilating itself in its close to the structure and mode of action which it had in its rise, as the cosmical law leads us to expect. At first it gives to creation in open space a small nebulous speck of æther (without any scaffolding), obliged by the unifying or synthetic action to give birth in its centre, by the simultaneous confluence of the ætherial elements there, to an atom, which is merely geometrical and dynamical, and which in the powers it possesses answers to the material element. At last it gives to creation, in the centre of the organism in which the material or molecular structure and action culminate, a large organised volume of æther (supported by an exquisite material or cerebral scaffolding), obliged by the more powerful unifying or synthetic action proper to it to effect the successive confluence of the ætherial elements in its centre or focus; so that, while the nebulous speck at the first commencement of ætherial synthesis can give to nature no more than a monad still blind and apathetic, and capable of self-preservation and sociality only in the forms of inertia and elasticity with attraction—that is, no more than a material element—this ætherial organism, on the other hand, due to cerebration and accompanying muscularity, gives in its focus of action a monad of vastly greater energy, a monad in which the mental powers proper to the primal substance of creation (after its attenuation in the ætherial element which reduced them to an aura merely), are recovered. Instead of mere inertia there is here conscious self-assertion; instead of blind attraction there is conscious desire, &c. There is, in short, as the proper offspring of this, the highest product of the material economy in our planet, the genesis of psychical beings, ultimately as in man, a soul or spirit, whose mother, nurse, and educator is thus the material organism and the terraqueous world.

Here, then, is the link by which the law of continuity is maintained throughout, and the cycle of things is made to be complete—the link which is missing in the popular science of the day, with this very serious consequence, that, to keep the break out of sight, the entire doctrine of spirit and the spiritual world is ignored or denied altogether.

As to the powers and dispositions which the individual mind will manifest, they must, of course, according to our philosophy, be co-ordinate with the individual peculiarities of the myo-cerebral organism in that individual; and their actual manifestation from childhood to old age, and from hour to hour, must be co-ordinate with the actual functioning of the cerebral apparatus at the time. According as that functioning is normal or aberrant in the individual, so must his mental manifestations be. This responsiveness of the mind to the brain is secured on a two-fold basis. First, there is the situation of the energy of the mind as centralised in the central region of the myo-cerebral apparatus, which under the cosmical law secures the assimilation of the thoughts and feelings as far as is possible to the existing mode of action in the myo-cerebral organism. And secondly, there is the relation on the part of the organism to the mind as mother and nurse, which under the same cosmical law secures assimilation again. Thus the mind is held by the brain, as it were, in double harness. But this is not an evil; for the mind can act and react from within itself with sufficient force; and but for the regulative action of the organism, which is to the mind the plenipotentiary from the kingdom of nature, imparting sensations and affections, and that higher regulation which comes from the imminence of the Deity, constituting reason and conscience, the mind would only curvet and kick and break loose altogether. Nothing less than all the bindings and brain-traces which actually exist would ever reconcile so quick a thing as the mind to drag on this mortal life and carry along with it to the end of the journey this inert heavy body. Nay, though the light of reason shone into it, still, if this were all, and it were a stranger to the pains of hunger and thirst, and the pleasures of eating and drinking, the highest order of minds would be the most neglectful of the necessities of the organism, and the first to be lost to the world. It is therefore no argument against the survival of the mind when dissolution overtakes the organism, that the manifestations of the mind are modified by the organism to the extent that they actually are; for nothing less would render possible such a mixed life as ours.

As to the special functions of the encephalon, both as a whole and as to its several parts, and the lesser systems which are compacted in the organism along with the central system, it is greatly to be regretted that historical anatomy has imposed such a multitude of names and even methods of inspection which are worse than useless. Unsuitable experiments also, even in the present day, have been followed by very unwarrantable interpretations. Nor is it to be expected, so long as the most tenuous and central regions of the cerebral apparatus are looked upon as of no account (though the important name of ventricles has been bestowed upon them), that much progress will be made in cerebral psychology, or the discovery of the residence in normal states of being of the centre of action of that mental force or substance which is supreme in man, and which, when all is right, holds in co-ordination with itself, and in subordination to itself, all the merely psychical centres that exist in the organism.

If there really be anatomical evidence for regarding the region of the corpora striata as that from which efferent action or muscularity issues, and the region of the optic thalami as that of afferent or sensation-awaking action, then according to this view the hemispheres would be a development co-ordinated with these two regions, a store of energy, a vault or concave reflector, having its focus of centrad ætherial pulsation, there where, consequently, there would be the birth and growth of the centre of energy of that being in which the access of motion generates feeling, and in which, reciprocally, feeling generates motion.

Being a true unity, and belonging as it does to the spirit-world already, it will escape at death from the little world of æther within, which has been its mother and nurse, into the great world of æther without, the realm of light, which is ambient to every deathbed.

To follow it into that realm belongs to theology. But even there theology can no more dispense with the revelations of science than science here can dispense with the revelations of theology. All truth is at once confluent and radiant in every direction. Thought in its spontaneity has the run of the universe; and there should be no bar to discovery, but sustained experiment that it cannot be made. No method adequate for all possible discoveries can be formulated in words. There is such a thing as inspiration, not for the poet only, but for the philosopher and the man of science also. Not method, but "happy thought," makes discovery. It was a happy thought in Newton that gave to science the idea of universal gravitation. The method now so much in favour—homage to observation alone—so often, as in that case, inaccurate, nearly cost the world that great discovery no one can tell for how long. Method is valuable chiefly, if not wholly, for preventing and for putting thought in order. Discovery is usually due to the spontaneity of thought discharging itself as a member, and to a certain extent as a mirror of the universe.

As to reality, the only adequate evidence or warrant for philosophic belief is the perfect harmony of all things believed, the support that all give to each.

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M

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PART I.

THE COSMIC LAW.

The physicist having for his theme the simplest data for thought, viz., time and space, and matter viewed as homogeneous and as consisting only of physical points, meets with fewer interruptions to a train of scientific thought than the chemist and physiologist, and consequently has been able to impart to physics a more continuous and scientific character.

This appears in his primary classification of the related phenomena into (1) *kinematics*, or the doctrine of pure or mere motion; and (2) *dynamics*, that of motion caused by physical force and applicable to nature.

Now when we proceed to specialise physics and to apply its beautiful results to nature in detail, as we see nature developing itself or already developed around us, it is possible to imitate successfully, I think, the primary classification of the physicist by regarding local movements as existing (apparently to the senses) in a statical phase, and thus producing finite forms, and creating a field for the science of morphology.

And here, learning to classify from the physicist, we may propose

(1) a Pure Morphology.

(2) A morphology treating of natural forms, which for a reason that will soon appear may be called Plasmatology.

This separation of form from substance, and the institution of a doctrine which while it is a purely mental construction, offers itself also as an explanation of the phenomena of material nature, depends on the echoing between thoughts and things when both are rightly conceived, and law applied in every case — a single law. The discussion of this law requires a metaphysical excursus which must be sought for elsewhere.* Meantime, by those who have acquainted themselves with it and applied it to phenomena, and found it to explain phenomena better than any other hypothesis they are acquainted with, though they may refuse their sanction to the method of its derivation (by pure thought verified indeed by

* See "A Sketch of a Philosophy," part i. and *passim*.

sensation, but not gathered from it), and though therefore they cannot lay hold of it by the head, may yet catch it by the tail.

Its full name, without being longer than many names with which modern science is familiar, might be the theoucosmogenetic law—the law of God, genetic of the cosmos. But omitting all possible syllables, *brevitatis causa*, and to avoid the twofold offence of innovating in names as well as things, we shall call it simply The Cosmic Law.

Assimilation.

In detail it is a law of all-embracing reciprocal assimilation both as to time and space. In space it produces the simultaneous assimilation of parts and particles on a principle of unity, and gives to nature symmetry along with individuality. In time it assimilates the future to the past, giving harmonious development and heredity. And in a word it produces the effect that every object tends to suggest and to mirror more or less either directly or inversely every other object; giving universal harmony, while all harmoniously unites in echoing the voice of the one omnipotent author of all, who is imminent and omnipresent in all.

This law may be illustrated by an allusion to that process by which our own organisation is continually reintegrated under continuous change and loss, and our life maintained from day to day, in reference to which the term assimilation is already in familiar use, though bringing along with the name no special light on the successive stages of the process except that they are seen to be cases at once of analysis or solution and of synthesis or reconstruction (as plainly they must be in order to assimilate things dissimilar) under the influence of agents to which there is now applied the name of ferments.

What these agents are, and how they act, is quite unknown to science. On these processes, however, our cosmic law does throw light, such light as may prove useful to dyspeptics and to the doctors to whom dyspeptics resort for relief.

Here, however, I shall mention only one condition (suggested by our law) to the successful assimilation of food.

The Ethereal Primal and Ultimate.

I allude to the fact that food when eaten must be dissimilar in some respect to the living organism with which it is brought in contact. If it be animal food for instance, and say that in itself it is identical with the tissues of the eater, it must be differentiated by being killed before ingestion, or at all events before the assimilative processes commence. But granting this difference—the difference between the dead and the living—the strain of reciprocal assimilation may take place, the living organism vitalising the dead food, and the dead food deadening the organism, as is indicated in the oppressed feelings of the dyspeptic and the gourmand after food, and the drowsiness of all creatures with full stomachs.

But I trace this process no further here. And indeed I have touched on it so far that I may state how the cosmic law acts when its only field is among objects that have been completely assimilated already. This is important; for it is to be considered that in this case the objects under it have already completely fulfilled it as to its reciprocal action. In this respect therefore they have nothing more to do. So much of the assimilative energy of each therefore as might have been bestowed upon the other is saved thus intensifying the assimilative action of each upon itself, (1) in confirming its individuality, (2) in preventing the intrusion of others on its rightful sphere of existence or volume, or (3) in liberating it so that it may assert that volume if it be in a state of confinement or concretion.

Hence the aeriform, ultimately the etheriform, is that in which alone an individualized particle of substance possesses all that belongs to it in its relation with space, and the continual operation of the cosmic law as dominant upon it tends to bring it into this state, as will appear hereafter.

From First to Last no Chaos, no Ruin.

When indeed we apply the cosmic law only partially, as for instance to universal assimilation in temperature, without regard to its concomitants, speculation obtains very sad results. But the same law, if applied all round, gives the universe at last, not as gathered together into one cold, dark, dead solid monument of its former self, but then, as now, a thing of progressive life and light and beauty, continually burning away indeed, but burning away into the aeriform, that is, into the most perfect form of matter, leaving what we call ashes behind, but ashes out of which arise objects brighter and better than before, yet necessarily perpetuating the same economy, being developed by the same law.

PART II.

PURE MORPHOLOGY.

By assuming mere points or positions in space, and placing them under the cosmic law, a definite system and economy of forms presents itself, of which the following are the heads.

Symmetry.

This is a name for the similarity of similar parts or particles in their relation to some one position, some one point or line or plane within the form. It may manifest itself in a greater or less degree. But wherever it appears it is explained intellectually by ascribing it to the cosmic law, the law of assimilation.

Sphericity.

As the symmetry of any finite system of points or positions whose tangent planes would enclose a space increases, two eminent stages may be noted, first, that which has one centre for all the points which constitute it, but these are disposed around that centre at different distances from it, except the equiradial series, which are equidistant from it and from each other.

Cellularity, Vascularity, Hollowness.

But a higher degree of assimilation and symmetry is attained when the positions which constitute the contents of the sphere proceed outwards so as to place themselves along with those which are there already at equal distances from each other, the whole system of points constituting the form being equidistant from each other and from the centre. The form now attained is the spherical cell, and in its development the cosmic law culminates, for plainly no more perfect assimilation of a system of points or positions which are to enclose a space or give a definite volume is possible.

Deformation, Diffusion, Radiation, Rotation.

But our points must be viewed as individuals as well as an united system, and in this case a much more perfect degree of assimilation than that which is attained in the cell is possible, viz., when they are all equidistant from each other or similarly in juxtaposition to each other,—a homogeneous extension in three dimensions, as in space itself. And in this arrangement they may accordingly be said to be assimilated to space itself.

The spherical cell must therefore be regarded as a transient structure depending on the sustaining power of its own individuality as a united system to resist the tendency of its own constituents and surroundings, which ever aim at its deformation and ultimate diffusion as consisting of so many individualized elements, each bent on asserting its claim as such to the full, that is, its own aeriform volume of space around it as the sphere of existence proper to itself.

Unification, seemingly Universally Reciprocal Attraction.

Suppose there are given two or any finite number of points at a greater or less distance from each other and perfectly mobile, the cosmic law requires them to be assimilated as to position. They must therefore move towards one another until they meet in one and the same place. They must seem to be guided by an universal attraction among themselves.

And now we have already an anticipation of those seeming oppositions and conflicts which nature so often displays. But it may here be seen that one and the same law may produce them according to its normal mode of action at the time and place. All is not a tending, as some physicists have concluded from seeing the law of assimilation verifying itself in reference to some one mode of motion only, to the utmost concentration and unity. It has for its coordinate in the economy of things the utmost diffusiveness as well. And hence the beauty and the variety of nature, everywhere weaving and unweaving and representing at once unity and omnipresence, the indefeasible attributes of the author of all.

The Inertia of Motion—Continuity, Persistence.

Any point considered as mobile must, when moving under the cosmic law, move along so that every successive element of its course shall be assimilated to the first. Now the first element of motion in every case is simply a change in position from the original to the next position adjacent, and this can never be anything else but an element of a straight line lying in a certain direction; and under the law of assimilation every successive element must be assimilated to those which have preceded. The whole motion must therefore be in the same direction, that is, it must be rectilinear. But under the same law similar lengths or equal lines must be described in similar or equal movements or measures of time. The motion therefore as it proceeds along must both be straight in point of direction and equable in point of velocity. It must be uniform. Moreover, if once entered upon, it must go on similarly, that is, for ever.

Thus there immediately results from the cosmic law acting in its simplest case the uniform phenomenon of inertia and the first law of motion.

The Inertia of Form—Elasticity, Heredity.

This inquiry cannot be carried far by mere insight, even by assuming the simplest forms or by the aid of the most advanced mathematics. If the permanence of the form in hand be provided for so that it is only subject to transient deformations, not to transformation, the law of assimilation provides that after every deformation the original form shall be restored under the condition of the inertia of the points in motion. Hence an everlasting vibration of the points and a phenomenon which would be an ideally perfect elasticity. But deformation and malformation have no place among the permanencies of the cosmical law. The action is ever aiming at the perfect, the infinite, with which however every finite form is at variance, but some more than others. That which is least at variance is the spherical superficies or cell. Hence towards this form whatever is capable of constructing it culminates.

But once constructed as a cell, its continuance in existence as such is all but over. It is forthwith called back to a form less symmetrical if it is to continue to exist, if not, it will be exploded or sublimed by diffusion into the infinite.

Vibration of Positions—Heat.

From the inertia of form (anticipating elasticity) it follows that a point which has once gone to constitute a form or a closed system of points can never, if left to itself, cease from entertaining a vibratory movement. And a whole system of points so disposed as to constitute under the cosmic law a molecule more or less in accordance with that law, must continue to vibrate round its centre and constitute itself a *punctum saliens*, until it be brought to rest from without.

And if there be two or more such systems face to face with each other, whencesoever they may have come, sooner or later they must be assimilated as to the quantity of vibratory action in each, the vibratory action of each point being less in proportion as the number of points in that system of points is greater.

The Simultaneous Institution of Opposites—Positive and Negative—Polarity.

A single movement can only be in one and the same direction at the same time. But all the while that it is going on towards new points, it is going off from those which it has reached already. Every single movement therefore has two aspects which are of the same character and yet are the opposites of each other. They therefore pave the way for such terms, constantly occurring in science as positive and negative, and sanctioning such symbols as plus (+) and minus (−).

Suppose two points to be fixed in space at such a distance that whatever the amount of their difference the cosmic law acting directly can do nothing to assimilate them; as, for instance, let one of them be a point of light and the other a point of darkness. Then let one or more mobile points be placed in a line between them, but not close to each other, or let them be restricted to keep as their trajectory the straight line between them, each will be repelled from that fixed point to which it has been assimilated and attracted towards that to which it is still dissimilar, according to the action of the cosmic law, which acts only to isolate objects which have fulfilled it. The mobile point or points therefore fulfilling the cosmic law of assimilation will be carriers of light to the dark points and carriers of darkness to the points of light. And the mobile points may, while thus placed and acting, be said to have each a photic or photiferous pole, and a scotic or scotogenous pole, which through custom and a homage to sensation we should no doubt name respectively the positive and the negative pole.

PART III.

APPLIED MORPHOLOGY—PLASMATOLOGY.

The mathematician having discussed kinematics or the doctrine of the motions of mere or pure points, proceeds to dynamics or that of physical points. In this there is a step in the direction of material nature. It postulates in the points physical force, especially inertia and universal attraction, and consequently regards them as possessing not merely a subjective or mental existence, but an objective, outward, or real existence. In a word, the points regarded are now substantial things, each occupying a definite position in space, and itself dissimilar to space itself.

Two Essentially Different Kinds of Substance formerly Assumed, viz., Mind and Matter.

It has been a very prevalent conception that this new datum of thought, viz., substance—besides existing in great variety—is of two essentially different kinds, the one mental and the other material.

They are not Coordinate.

But since in the investigation into knowledge of any other subject whatever or into knowledge itself, we always find ourselves in the last analysis dealing with the phenomena of mind, and as to the phenomena displayed to us by matter, can know them only by mind and in terms of mind, while in neither case we can get beyond phenomena except in the naturally non-reasonable affirmation of substance, it seems wisest not to double that affirmation by setting out with two kinds of substance essentially different, but with one only, and proceed to inquire whether the differences in observed phenomena may not arise from differences in the conditions of existence of that substance.

Mental Substance the Primordial Unity.

If this be agreed, it is certainly mental and not material substance which has the claim to be this primordial unity. And the question would stand thus—given a mental substance such that it is capable of manifesting all the mental phenomena known to us, sensation, perception, thought, volition, may it not be inferred by a most extensive observation of the economy of things that by attenuation less or more that substance may lose its power of manifesting these higher phenomena, until at last no power remains but that which seems to be of the very essence of mind, viz., activity, implying (1) the power of effecting change within itself, and (2) the power of effecting change in the outward, as for instance that of appearing or manifesting itself to others; the former power (intrinsic activity) being *the last traces of volition*, and the latter being that by which belief in external existence is awoke, *the correlative of perception.*

Accordingly some time ago physicists who did not avail themselves of the elementary dichotomy of existence into creator and creation, substituted for it the dichotomy of matter and force. Of late, however, a finer analysis has found that matter is known only by force and in force, and moreover that such is mind as it exists for us and in us, that nothing but that which is a manifestation of some kind of force can be known to us. There is a growing conviction therefore among materialists as well as others that substance in the last analysis is a thing of life and power, a spirit-nature, a "mind-stuff."

How this View may be Scientifically Wrought Out.

Let this view be adopted, and let the following data be granted with regard to the substance conceived.

Cosmic Substance Finite.

1. That its quantity in existence, however vast, is yet finite.

Divisible—Diffusive.

2. That it may be partitioned or individualized to such an extent that each individual element of substance is next to nothing as a force, being, or thing. Meanwhile, though with loss of individualised force, substance has thus gained diffusion throughout the universe.

Confluent—Monadgenous.

3. That such or any elements of substance may become confluent into unities (monads) of greater value as powers, recovering mental faculties proportionally to their quantity in the individual, in virtue of the postulate that substance is essentially mental substance or the basis of mental phenomena.

Two Phases of Existence under Cosmical Law.

And for these phenomena and all phenomena let it be unattenuated or exist in quantity, and (1) let it be wholly and solely obedient to the cosmical law bearing upon it as external to it, that it may be assimilated in its attributes to those of the author of all (the primordial mind), until it acquires such power as an individualized being that it can move freely in the depths of its own activity, and manifest free will, and for the time become an originator of acts and its own universe; and (2) let this volitional phase of isolation be destined to pass off while the light of the cosmic law shines fully in it as well as upon it and directs its choice.

Ultimately, therefore, and when entering normally into the system of the universe, and when on the way of its own well-being, the substance conceived depends for all its phenomena on its intrinsic life and spirit-nature, and the play upon it from without and from within itself of the Theoucosmotectonic, more shortly the cosmic law.

The Genesis of Physical Force.

The cosmic law is the fountain of physical force. It may be illustrated by the familiar phenomenon of the weight or gravitation of bodies. Plainly, however, this is not a simple phenomenon; we can conceive even a large thing moving spontaneously downwards and hitting our toes without hurting them.

Mental analysis resolves the phenomenon of gravitation into the two following components, viz., universal aggregation and inertia.

The Unifying Force.

Given two or more morsels of substance so attenuated by partitionment or individuation that they are no longer capable of manifesting mental phenomena, but only their own existence, then it follows under the cosmic law that that law must tend to assimilate them as to their positions in space. They must tend towards the same position as if they were actuated by a mutual attraction.

The phenomenon may be fairly regarded as the residuum of the mental phenomenon of sociality.

Actual Inertia.

Referring to our pure morphology on this head (p. 7), and instead of a point substituting a morsel of substance similar to that conceived in the last paragraph, the actual phenomenon of inertia plainly emerges, and there is given to nature what is usually called the first law of motion, implying weight or pressure in the direction of motion.

Divisibility.

Substance though thus ever tending to identity in position and therefore to complete unification is yet divisible, individualizable and diffusible to all but an infinite extent, the cosmic law requiring it to assimilate itself to the whole of space to the full extent that that which is finite can assimilate itself to that which is infinite.

The Universal Ether.

When partitioned so that each morsel is a minim and next to nothing, though still each an unity and diffused to the utmost degree compatible with the preservation of all the particles in relation with each other so that the whole may still possess a certain degree of unity, the substance conceived as in this state constitutes the ether. It does not either in its particles or as a whole manifest any mental phenomena itself directly, but it shows its relation to these phenomena by its powerful assistance to them as the medium by which embodied minds are enabled to perceive distant objects, as light, the affinity of which to mind has been constantly recognized.

Matter.

The quantity of ether being finite, its particles under the cosmic law in regions where a synthetic phase of existence prevails must tend to be assimilated as to position. A certain number must group themselves around a common centre. They will not at once rush in upon that centre and become confluent there. Because, having been once individualized for an unknown epoch the cosmic law acting as the law of heredity and tending to assimilate them in their new situations to what they were when diffused to the utmost will prevent their immediate confluence, preserving their previous individuality, admitting them only to remain in juxtaposition and constitute a group of etherial elements which for convenience we have called a nebular speck.

But as the group increases in the number of elements constituting it, the urgency or pressure of all its constituent to be assimilated in position and therefore to press towards the centre must increase. Hence an epoch must arrive when the central pressure is able to overcome the individuality-preserving power of the constituent particles, and those nearest the centre will become confluent. And thus we obtain a new mode of substance, viz., a monadic nucleus invested with its atmosphere of generating ether. And this according to our view is the material element or atom or true unit of atomic weight; for the etherial elements being all under the cosmic law identical with each other except in their positions in space, the central pressure causing confluence and generating nuclei in the nebular specks must effect these nuclei when the speck consists of the same number and quantity of substance in all. In the last analyses of an adequate chemistry, therefore, while the educt is still entitled to the name of matter, all material elements are identical except as to their positions in space.

And here therefore our views depart entirely from those of modern chemistry, which regards the particles of all undecomposable substances which are different from each other as different kinds of matter, not to be transmuted in each other anywhere in the universe—because forsooth this cannot be done by man at this particular time in this small cold planet which happens to be our embodied dwelling-place for a few minutes in an eternity !

The Atom.

The senses of touch and of sight take such a lead over those of hearing and smelling in determining our popular views of things that they prompt us always to ask the size and form of objects, meaning the planes of demarcation between these objects as indicated by the senses and the external space—the very conception of which implies a breach in the law of continuity. Now the habit of mind having such an inadequate origin must be quite put away from us if we are to have any rational idea of force. Happily for this view it is held as part of the Newtonian philosophy that every atom in the universe attracts and consequently acts on every other atom, implying an extension of reciprocal action on the part of all atoms to the remotest distances; and indeed without sanctioning this view it is necessary if we are to have any intelligent conceptions of the functioning of atoms at all to consider each atom viewed as an object of sense as a "nucleus" merely invested to an unknown but vast extent by an abiding or continuous effluence or radiation of assimilative thermo-electro-magnetic force.

As to the nucleus of the atom, considering the innumerable number which can be accommodated in what we call a very small space, we are tempted to regard that nucleus as merely a physical point or centre of force. But it is certain that any individualized thing which exists in space, however minute it may be, yes even a physical point as a thing of nature and not merely of mathematical conception must have a definite form and magnitude. And it follows obviously as will be granted on referring to our pure morphology (p. 7) that the form of the nucleus of the atom must be a sphere whose constituent particles are assimilated to each other in position to the utmost; and therefore that the atom is a spherical superficies merely or cell, though inconceivably minute yet real.

And as to its assimilative atmosphere of force, all the successive wavelets, whether peripherad or centrad, which constitute it must be spherical also concentric with the nucleus and with one another.

The consumption of spirit-substance in constituting matter is thus a minimum.

Molecules.

As the etherial elements in the celestial spaces aggregate into nebular specks whence atoms of matter result, so under the same law, atoms of matter aggregate into molecules. But the atom along with a great recovery of power generally over the ethereal element has a great increase of power in maintaining its own individuality also, its self-assimilative or self-sustaining power. Consequently when atoms aggregate into molecules, no confluence takes place of those in the centre. It may be, however, that in very highly composite material systems new unities of the primal mind-stuff of creation or mental monads are developed.

But in this planet the atoms constituting the molecule exist in juxtaposition only not in confluence. And thus the field is given to nature for physics, chemistry, and petrology.

Molecular Movements.

The phenomena of molecular and intermolecular action presuppose elements which, from their history of their genesis or the want of material, cannot assume at once a spherical and cellular structure. Hence the cosmic law, in virtue of its proper pulsatory action or specific heat, is always keeping molecules in motion, moving their particles towards the maximum of symmetry, that is, the spherical and the cellular. This, however, only a few light and versatile or polymorphous molecules commonly called organic can actually attain.

Metamorphism.

Hence secularly or in very long periods of time mere stoney and mechanical deposits tend to become granular and crystalline, especially (1) in regions which formerly have been or still are actuated by more powerful heat, or (2) where the assimilative influence of previously existing crystalline matter acting in their neighbourhood produces the same effect as heat.

Fermentation.

Very soon also, molecules and molecular unities, which are very active and changeful, especially if manifesting life, when introduced into a volume of matter liquid or solid which as it exists tends towards change, alter it assimilatively—and that always in the interest of molecular perfection, viz., the spherical and cellular or the aeriform state.

To this mode of action chiefly, and the many different ferments provided in the course of the nutritive canal to assimilate the different kinds of food we eat, our living tissues, our life, in spite of a daily and hourly loss which is severe, and if we are active creatures inevitable, is maintained, it may be, for the best part of a century, a longevity which may perhaps be reached hereafter in its integrity, when the laws of hygiene are well understood and fully respected.

Molecular Force.

Power or force (not quantequivalence) in general in individualized objects is, according to our view (*cæteris paribus*), proportional to the quantity of our protoplasm which constitutes them. The force of molecules ought therefore to be proportional to the number of atoms involved in their structure, and therefore to their atomic weights. And that it is so fully appears from observation, though verification is difficult where so many other features of molecules as well as their atomic weights enter into and determine their functioning. But disregarding those which have dissimilar forms and structures, the following, which, generally speaking, are isomorphous, when properly mated or tested, plainly increase in power as their atomic weights increase, the lightest being named first.

Chlorine, Bromine, Iodine.
Potassium, Rubidium, Cæsium.
Magnesium, Calcium, Strontium, Baryum.
Sulphur, Selenium, Tellurium.
Phosphorus, Vanadium, Arsenic, Antimony, Bismuth.
Boron, Carbon.
Ozone, Fluorine.

Atomicity.

Elements according to the number of places on their surface, especially their polar and equatorial regions, which are suitable for attaching other elements to them, are said to have different atomicities, a fact which assists greatly in developing the variety of nature, and forms a fertile subject of scientific observation.

Absolute atomic weights = H = 5, C = 30, O = 40, Ⓓ $= O_2 = 80$, N = 35, Az = 70.
Conventional H = 1, to many chemists C = 12, O = 16, N and Az = 14.

Molecular Activity.

This is in the main dependent on form and structure, and the quantity of the generating ether which the nucleus has succeeded in carrying along with it. The further it is from being spherical and cellular, and therefore the more work that is before it in order to the fulfilment of the cosmical law, the more active or disposed for action it is. Yet its inertia is such a hindrance to its activity that that activity may be said (*cæteris paribus*) to be inversely proportional to its atomic weight, and therefore inversely to its force in general.

The type of locomotive activity is hydrogen, of parasitic activity, fluorine; and of very long lived stability, silica and other gems.

PART IV.

NATURE.

But there is no such thing as perfect rest in any molecular structure in nature, no ultimate immutability, nothing permanently dead, no absolute cold. There is molecular action everywhere.

And all molecular action is cyclical, wholly or in part.

The cosmical law fulfilled in any case, then by the analytical and synthetical action, both of which are implied in that law, the structure which has so fulfilled it proves to be resolvable into quasi-embryos fitted to restore it to nature out of its own ashes.

$$\text{Thus, } SiO_2 \left\{ \begin{matrix} Si_2 = 2\,Li = 2\,CH \\ \&c. \quad \&c. \\ O_2 = AzH_2 = C_2H_4 \end{matrix} \right\} = 2\,LiO = 2\,CHO.$$

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