An attempt to show that light, heat, electricity, and magnetism are effects of the law of gravitation.

Wallace (Wm Cary)

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BY W. CLAY WALLACE, M. D.

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LIGHT, HEAT,

ELECTRICITY AND MAGNETISM.

Light, Heat, Electricity, and Magnetism have been called Imponderable Bodies, although there are no facts to establish that they are material. There may be aqueous or other vesicles filled with, and floating in the air, without essentially altering its constitution; but the existence of *bodies* which cannot be detected either by their own weight or chemical union with others, is incompatible with known laws. If it can be shown that the effects are produced by disturbance of the equilibrium of bodies, by change of density and distance, the explanation of the phenomena will be simplified by being brought down to one cause.

In order to be understood, repetitions and assertions of what is mere hypothesis could not well be avoided; yet it is not more problematical to account for the law of interference of light by the supposition of a non-polarized cell of that which we can confine in a jar, and weigh, and analyze, than by the confluence of the waves of an imaginary ether; and it is not more problematical to explain by the same cell the elevation on both sides of a perforated card, than by the presumed existence of two imponderable fluids.

In the following attempt, we shall treat the subject in inverse order, from the common classification, by commencing with Magnetism.

Magnetism.—If the sun and planets be taken as an illustration of a system formed by immense masses of matter, the organized cell may be regarded as an example of those which are minute. In accordance with the law that matter is attracted towards matter with force proportionate to the square of the distance, bodies on the surface of the earth are most forcibly attracted to its own centre, yet they are also attracted by the matter of the sun, the moon, and the atmosphere. Owing to gravitation and the mobility of its walls, the organized cell, unable to maintain a spherical, assumes an ovoid form. A number of cells, if placed in a tube, would present their greater hemispheres towards the earth, and the lower cells become compressed

in proportion to the weight above them. It is presumed that the moment the tube is turned in a perpendicular direction, the cell nearest the earth is first and most powerfully attracted, and that the ovoids are formed in regular order, but with such inconceivable rapidity that the eye cannot detect the period of successive formation.

If, as the granules of a nerve are enveloped by neurilema, we could arrange the cells in a tube of nearly the same diameter with themselves, and so adhering to its walls that no change of linear position could be effected, all would become ovoid, and present the greater hemisphere towards the principal attracting mass.

A boy's sucker applied to a stone affords a familiar illustration of the principle that the gravitation of the stone can be overcome by cohesion, or attraction, at insensible distances. If, therefore, a cohesive force exerted at one extremity of the tube we have supposed, causes a succession of changes in the forms of the cells, we may account for cohesive attraction at the other extremity.

The egg of the domestic fowl is an enlarged example of the cell we have been considering. Before the addition of the shell, it has acquired the usual shape by gravitation, but after being covered it becomes permanently polarized. For reasons now to be given, we shall call the greater hemisphere the north, and the smaller the south pole. If the egg were placed longitudinally on a pivot, the greater hemisphere would preponderate, and if without change of position the contents could be drawn the other way, the effect would be reversed. On the inequality of the hemispheres of primitive cells so disturbing the equilibrium between the earth and the air, that their mutual attractions become greater in one place and less in another, our theory is founded.

From the granular structure of iron, it is inferred that the inorganic matter is arranged in cells as described, with the greater hemispheres directed towards the greater attracting power. A bar of this metal, when held perpendicularly, becomes a magnet; the lower end behaving as a north, and the other end as a south pole. The magnetism thus induced is temporary, but after hammering, the acquired polarity is not altered by change of position. In the latter case the successive molecular changes produced by attraction at one extremity, cannot be so easily communicated to the other; hence a slight change of molecular arrangement diminishes or prevents the power of transmission. In this way it is presumed the particles of water conduct impressions when fluid, but when changed into ice, the cells become permanently polarized, and do not conduct them; in this way, too,

amorphous carbon is a conductor, but when crystallized, it becomes a non-conductor.

In afterwards referring to conductors and the electric current, we do not mean to express the idea of a stream of an imponderable fluid passing through a cohering body, but successive molecular changes in the conductor, effected by cohesive attraction at one terminus. The change of condition in the conductor influences both air and earth, and when the termini touch the earth the metallic particles and the ground beneath them resume their natural positions: by retrograde motion both lines arrive at the original point of disturbance, and leave all behind them as before. Although not a fair example, transmission may be illustrated by placing a row of books on end, and some distance apart, in the way that boys amuse themselves at school. When the first book of the row is thrown down, all the rest fall in regular succession; and if we now suppose that gravitation could be counterbalanced by elastic springs representing the air, the books would resume their first positions. Excited conductors may be compared to soft iron magnets, in which the power is greater in proportion to the length of the rod, and when communication is effected by transmission from cell to cell, as in a galvanic trough wrought by innumerable air-pumps, or vacua produced by the oxydation of zinc, the effects become intense. As when one bar of iron is placed upon another, the lower end of the uppermost bar presents a north, and the upper end of that which is in communication with the earth a south pole, it is inferred that iron is always magnetic by position.

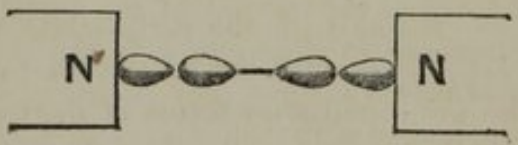
The air or other medium in which a magnet is placed, acquires polarity similar to that of the metal itself, and is arranged in curves, the direction of which may be seen by iron filings, or still better, by black lead sprinkled on a plate of glass laid over the magnet. The curves proceed from foci at the termini of the metal, and advancing from cell to cell, increase in diameter with the distance from the terminus. The air around a magnet may be compared to a number of cut elastic rings, arranged with their convex surfaces to each other; the middle third tied up in a straight bundle, and the loose termini forming curves in straining to be restored to their original condition. The air around a magnet may also be compared to a positively or negatived electrized bundle of hair, which diverges by the attraction of the atmosphere, and under favorable circumstances bends, to restore the equilibrium or complete the circuit.

The influence of the atmosphere on bodies polarized in a certain manner, may be illustrated by one of Prince Rupert's drops, which are prepared by pouring melted glass into water. The water being of

a lower temperature, the outer surface of the glass is immediately congealed. The north poles of the cells of the glass will, on cooling, be directed to the particles of the circumference, and the centre of gravity of the mass will present a point of no attraction. When the surface is broken, the particles of the glass being attracted by the air, fly off in all directions; an explosion ensues, and the mass becomes dust. In like manner, when the south poles of two magnets are brought near each other, the north poles of the air cells are presented to the iron, and as there is no central point of attraction at the meeting of the lines proceeding from each magnet, the metals drawn by the surrounding atmosphere recede from each other.

Both cases may be illustrated by Faraday's experiment of the electrized muslin bag, the fibres of which diverge equally, whether positively or negatively excited. No attractive force within the cone can be discovered by the electrometer; and when, by silk threads, the bag is turned inside out, the effects are precisely the same.

The earth, as has been stated, becomes ant-arctic to the bar of iron, yet the earth itself becomes arctic to the sun, and zinc becomes arctic to platinum, although it is ant-arctic to oxygen; it is therefore presumed, that when two north poles are brought near, the iron attracts the north poles of the aircells, a negative centre is formed as before, and similar results follow.



When opposite poles are placed near each other, the south pole of the one magnet influences the air cell in contact with the north pole of the other, and the north pole in its turn influences the air cell attached to the south pole of the other, with force proportionate to the distance, so that neutralized by opposing forces, one of the cells at or near the centre of the intervening line presents a new centre of gravity, to which the magnets are not only attracted themselves, but impelled by the surrounding atmosphere.

North Pole.—As by the coil theory, the magnetic poles would be placed at the axes of the atmosphere, we shall attempt another, and endeavor to give reasons why one pole of the mariner's compass should be directed to the northern rather than the southern hemisphere.

We have seen that polarity is affected by comparative density, and that the denser body is generally ant-arctic. As land is denser than water, we might expect that the centre of gravity of its surface would, as in other cases, present a south pole. In order to determine the position of this centre, it is necessary to take into account inequality of attraction by difference of elevation, and the effect of vegetation in increasing the extent of surface. By looking at the map, we perceive that most of the land exists in the northern hemisphere, and that south of the magnetic equator there is scarcely one-half of South America, one-third of Africa, and the continent of New Holland. On the eastern hemisphere there are many unproductive surfaces, such as the African and the Arabian deserts, the steppes of Tartary, &c. whereas on the western the foliage is luxuriant, and the land projects farther south. On the eastern hemisphere the woods have been cut down to allow for its millions of inhabitants, the cultivation of food, the growth of which causes an easterly deviation of the compass from May to the summer solstice, when the grain ripens and is cut down; whereas, on the western the forests far exceed the area of the land cultivated for the support of its comparatively sparse population. The location of the magnetic pole on the western side of the axis of the earth might thus be inferred from theory, if it were not pointed out by the compass.

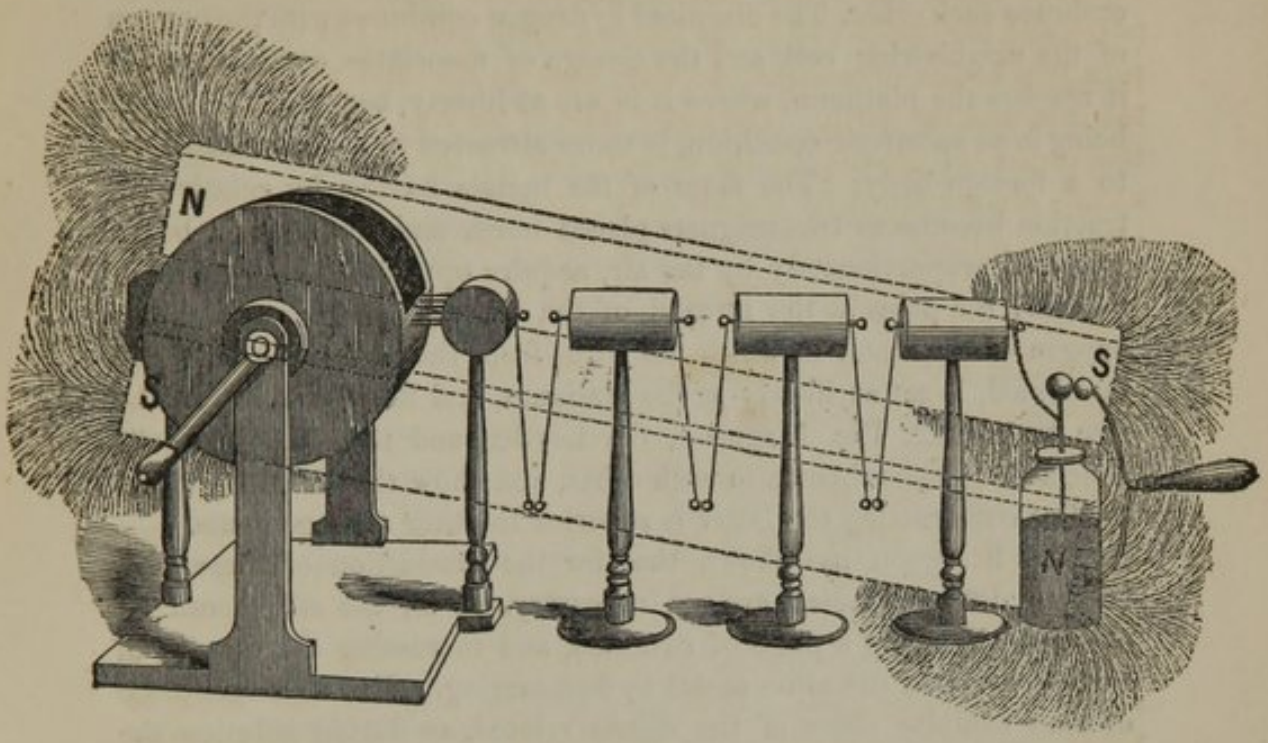
Electricity.—All the elementary forms of matter, with which we are acquainted, differ in specific gravity; yet the same element may, by becoming porous, crystallized, or chemically combined, be rendered specifically lighter or denser; thus the specific gravity of silex, when it constitutes the yellow covering of straw, is different from that of quartz. The enamel of the teeth, and the petrous portion of the temporal bone, are denser than other osseous structures. Even scratching the surface, or coating one metal with a thin film of another, essentially alters the behavior of bodies in producing electrical phenomena.

We have seen that the lower end of the rod of iron presents a

north pole when directed to the ground. If we were to place the rod on another bar of this metal, directed in the same way, and then separate them, the lower end of the former would still present a north and the upper end of the latter a south pole. Let us now compare two bodies of unequal density, such as zinc and platinum, with the iron and the earth. The outer cells of the zinc being drawn from the centre of gravity by the denser mass of the platinum, should, if metals are governed by similar laws, present the north pole, and the opposite cells of the platinum, being only partially drawn out by the weaker metal, should present the south pole, just as the cells of the ground or those of the upper portion of the iron rod are elevated by the weaker attraction of [redacted] the atmosphere. If the platinum be roughened, pointed or made porous, so as to produce unequal distances between the metals, or, so to speak, to allow the attractive forces to proceed from foci, the effects are increased. Glass when rubbed with any body presenting unequal distances, such as silk, feathers, &c. or with mercurial amalgam, becomes on the same principle in an arctic condition, and attracts bodies repelled by sealing-wax; whereas sealing wax treated in a similar manner becomes ant-arctic, and attracts bodies repelled by glass. Both have become magnets, but owing to the polar arrangement of the one, and viscidity of the walls of the other, the cells do not possess that freedom by which metallic cells are permitted to alter and arrange their poles. When a magnetic needle is presented to excited glass or sealing-wax, the needle is attracted without discrimination of pole, because the air around the excited body, by becoming similarly affected, prevents that nice atmospheric balance on which magnetism depends. It may be shown by experiment that under fair circumstances the needle will be not only attracted to the excited body, but the excited body itself will, if permitted, point due north and south.

When the cylinder or the plate of the electrical machine is turned round, the glass becomes arctic and the rubber ant-arctic. The cells of bodies in the air and those on the ground may be compared to the conducting wires from a pair of galvanic plates, the termini of which are in opposite polar states; or they may be compared to those of two curved magnets placed above and below the machine, the south pole of the one representing the cushion, and the north pole of the other the electrised glass. As the pole of a magnet changes at a short distance from the commencement, south poles are presented at the teeth of the prime conductor, by which the north poles of the metallic cells are collected in foci. A series of insulated cylinders placed near the prime conductor become similarly affected, and resemble as

many magnets pointing in one direction, and attracting bodies which have acquired opposite polarity. When a Leyden jar is connected



with one of these cylinders, the lining tinfoil becomes in a like condition, and electrizes the inner surface of the glass. The inner and the outer coatings of the jar bear to each other a relation resembling the cylinders; for if the jar were placed horizontally on a glass pillar, and the outer covering turned inside out and also insulated, two additional conductors might be added to the series. When suspended in air, which is an imperfect conductor, the jar can be only moderately electrized; but when the outer surface is in communication with the ground, the inner surface can be highly charged. Although glass, by reason of the unchangeable polarity of its walls, prevents restoration of equilibrium, it presents no obstacle to the attraction of bodies beyond it, as may be illustrated by rubbing one side of a piece of window glass and placing light bodies on the other side, and also by the divergence of the electroscope in a vacuum. The coatings of the jar may be regarded as the termini of the magnets with which we commenced the comparison; the outer coating or terminus of the cells of the earth being now in an arctic, and the inner coating in an ant-arctic condition.

In an arctic condition water is to zinc as zinc is to platinum. In accordance with this principle, when a plate of each of these metals is

immersed in an acid solution, the oxygen or arctic portion of the water cell is attracted by the zinc, which in its turn is attracted by the platinum, and by the opposing forces the elements are made to embrace each other. The disunited hydrogen combines with the oxygen of the neighboring cell, and the change of associates continues until it reaches the platinum, where it is set at liberty, because the metal, being in an ant-arctic condition, is more attracted to its own mass than to a foreign body. The faces of the metals having by relative attraction become as two magnets placed north and south, their backs attracted proportionately by the air, acquire opposite polarity, and in this way the poles at the termini of the battery are reversed. The oxygen of the water in which the wires from the opposite plates are immersed, is set at liberty at the platinum, and the hydrogen at the zinc terminus. The Magnetic, the Leyden and the Galvanic cells bear a close resemblance to each other, and show that Faraday's method of constructing the latter is superior to other arrangements.

Mr. Sturgeon has shown that for the production of these phenomena different metals are not necessary, as all the effects can be exhibited by using a plate of cast zinc, and increasing the density of another plate of the same metal by hammering. Even a single piece of zinc exhibits some of the effects related, as during solution the lower portion becomes arctic and unites with oxygen, whereas the upper portion becomes ant-arctic, and gives off hydrogen.

It was discovered by Dobereiner that when a stream of hydrogen was passed through porous platinum, the metal became red hot and the hydrogen inflamed. Water is formed by the separation of the oxygen of one of the air cells in the spongy mass, and its union with hydrogen, and the protoxide of azote is produced by the decomposition of another. When a mixture of oxygen and hydrogen gases is detonated, the condensation of the elements thus drawn together is so rapid, that a violent explosion is produced by the action and reaction of the surrounding air. In like manner by the chemical union of the constituents of the cells contained within the porous platinum, vacuum after vacuum is produced, and a current of air established to supply the place of the dissipated elements.

Heat.—As the disturbance of equilibrium necessary for the production of flame is great, combustion cannot take place when the temperature is diminished below the proper point, as may be illustrated by Davy's safety lamp. It would be unfair, therefore, to expect that all the phenomena of light and heat would be produced by low degrees of inequality of attraction.

When porous carbon is placed in a common fire-place, a certain

amount of disturbance of the equilibrium between the earth and the atmosphere is necessary for the union of the carbon with the oxygen of the air, just as we bring metals to a certain temperature before making an alloy. The oxygen is then attracted by the denser carbon, a current of air is established, and the dobereiner battery feeds itself. The wick in a candle and the coals in a fire burn more brightly after part of the carbon has been consumed and a porous crust been formed.

When the pores of the dobereiner are large, as in the lungs, the relative attractions are diminished, and being restrained by the continuous flow of the blood, the temperature does not extend beyond a certain degree. Here, also, disturbance of equilibrium is required to commence and continue the process.

When the pores of the dobereiner are of minute description, as in carbonate of lime, or semi-burned alumina, the combustion of a mixed stream of oxygen and hydrogen gases is complete, by being accomplished by little at a time, and in rapid succession. The combustion thus effected by continuous chemical action, polarizes the air to a great distance, and the light is so intense that it can scarcely be borne by the unprotected eye. When the poles of an excited galvanic battery are brought near each other in common air, chemical action ensues; some of the nitrogen is set free, and protoxide of nitrogen is formed with the sensations of heat and light, as related.

By disturbance of the equilibrium thus produced, the cells of the wire will, by attraction of the atmosphere, recede from each other and become expanded. This is the law of expansion.

By continuing the experiment, the metal falls down in drops. This is the law of fluidity.

Any vaporisable, solid, or fluid body placed at the poles, assumes the form of vapor. This is the law of vaporisation.

A new centre being formed by placing a red hot ball or a piece of ice in the focus of a parabolic mirror, the cells of the polished metal acquire new polarity, which may be communicated to another mirror placed at a distance, in the focus of which the air in a thermometer will be expanded or contracted. This is the law of radiation.

We have gone on the theory that every collection of matter represents the universe, consequently every globule of mercury resembles a world, the cells of which are not only attracted to their own centres but to the centre of the mass to which they belong. When the counter-attraction of the atmosphere is diminished, attraction to these double centres is increased and the volume becomes lessened. On this principle the thermometer falls when placed in recently rarified air, whereas it rises in a combination of sulphuric

acid and water, because the specific gravity of the latter mixture is greater than the mean. On the same principle also, the summits of lofty mountains are covered with snow, because there is less atmosphere above them to keep the particles so far asunder as to constitute fluidity; and when we descend from the surface of the ground the temperature increases, notwithstanding the unproved assertion that we are treading over molten lava; and on the same principle bodies which are solid at the poles, are fluid at the equator, because there the attractive force of the atmosphere is greater, on account of its greater diameter, the effect of which is counterbalanced by the increased distance between the surface and the centre of the earth.

It has been repeated that when the attraction of the air is diminished, central attraction is increased. Were water the fluid evaporated, the water cells would be compressed into a fluid when the equilibrium is restored. It is possible that at the commencement of fluidity the water cells are so arranged that they form hollow spheres, as it was observed by Saussure that the mist by which he was surrounded on Mount Blanc was formed of aqueous vesicles. If the vesicles were broken, the water cells would be drawn together and a new centre of attraction would be formed. It is also possible that when the atmospheric attraction is diminished to 40°, gravitation is counterbalanced by the breaking up of the cells into smaller spheres; and by the new attraction of each cellule to its own centre, the mass expands and acquires greater fluidity. On further diminution of temperature the cellules acquire a solid form, and, crystallizing into ice, float on the surface of the liquid. In the same way sulphur on cooling becomes thick at a certain temperature, it then acquires greater fluidity and again expands on crystallizing; and iron and antimony, the most easily polarized of the metals, expand when becoming solid.

Having briefly noticed the effects produced by the action of unequal masses of matter on each other at unequal distances, we shall now make a few remarks on their arrangement.

I. The Earth and the Sun . . . *Geoheliac Battery.*
II. The Earth and the Moon . . . *Geoselenic Battery.*
III. The Northern and the Southern Hemisphere . . . . . *Austro-Boreal Battery.*
IV. The Earth and the Atmosphere . *Geopneumatic Battery.*
V. Unequal Terrene Bodies . . . *Allobarytic Battery.*

The two last may be subdivided into those by which change of polarity is effected by alteration of—

1. Position; *Gilbert's Battery.* 2. Temperature and State; *a.*

Seebeck's Battery; b. Armstrong's Battery. 3. Chemical Constitution; *a. Dobereiner; b. Galvanic; c. Botanic; d. Zoonic Batteries.*

Some of these have been already noticed, and others will be more appropriately mentioned when considering Light.

Austro-Boreal Battery.—Although the surfaces of land and water are only edge to edge, yet the columns of air arising from them being face to face may, when in opposite conditions, give rise to the storms which occur with most violence at what might be considered favorable localities, such as the inter-tropical islands and the capes.

When any irregularly formed body is balanced on a pivot on the prime conductor of a machine, it moves in a circle with velocity proportionate to the extent of electrization; and by the rarefaction of the surrounding air, thermometer and barometer fall. As there is mutual attraction when currents move in one direction, and repulsion when in opposite directions, a cloud even moderately electrized, finding those around it in a proper condition, and moving the same way, may by adding to its bulk and force, become a storm, sweeping over the sea until it reaches the columns from the land, which revolving in a different direction, keep the tempest at a distance by a force as powerful as its own.

Botanic Battery.—Every tree may be considered a galvanic battery, with its leaves forming the divisions of the trough, the poles of which are the branches communicating with the air and the roots penetrating the ground. As the metal in electro-plating is set free from combination, and deposited at the south pole of a battery, the carbon contained in the atmosphere is deposited on and constitutes a part of the leaves, which electrized by the sun, fulfil the double office of lungs and heart.

Two microscopic plates of unequal power become a germ or battery, which converts the starch of the grain into sugar by digestion, and appropriates the prepared nutriment to its own growth. After this process, analogous to the incubation or gestation of animals, is accomplished, the plant, obliged to provide for itself, sends roots into the soil and extracts other materials, which it previously prepares, by acting on a stomach exterior to its body.

There are not yet sufficient facts to explain why it is that when a vessel of water is placed within fifteen inches of a gourd, a leaf of the plant will be found floating on the water on the ensuing day? or how it is that a scarlet runner will approach a pole, placed at the distance of a foot or more, then follow the pole when moved in an opposite direction, and die if the change of position be too frequent?

Many of the effects which are usually attributed to inorganic chemistry, are in reality produced by vital functions; thus vinous fermentation is effected by a minute fungus which, growing with great rapidity, evolves carbonic acid and converts a portion of the saccharine fluid into alcohol. By fungi of one description certain fluids may be converted into vinegar, and by those of another they may become putrid. Thus decay is not effected by any immediate alteration of chemical composition, but by myriads of minute batteries evolving gases at their tiny poles, and restoring the body to its original elements.

Diseases, both of plants and animals, are for the most part caused by vegetable or animal parasites; thus the ergot of rye is a vegetable, and the curculio of wheat an animal. The muscardine of the silkworm is produced by a cryptogamic plant which grows on stones, yet grows also in the intestinal canal, and by causing it to rot, the animal dies. The aphthæ of children are fungi, a portion of which taken from the mouth of one child may be propagated on the surface of milk in a vessel, and afterwards communicated to another child.

Most eruptive diseases run a certain course and reproduce their own species, according to the laws of organic life. The viscera of the body are not exempt from foreign ravages, as tubercles, cancers, &c. may infect the lungs, the brain, or the liver. As most fungi thrive best in the dark and die when exposed to the sun, so morbific parasites are often found in animals, which, created for exposure, are kept in the shade; thus stall-fed oxen are seldom free from diseases of the lungs, whereas those which roam in the fields are generally healthy. Among those who dwell on the shady side of the Alps, scrofula and mental imbecility occur in the worst forms, yet the individuals who dwell on the other side of the mountains are the healthiest of the human race. Although it is apparent that consumption is most frequent among those who are kept within doors, the thoughtlessness of those who submit their children to the modern system of education, by which they are confined for hours during the choicest part of the day, is remarkable. A potato or other plant growing in a room through which there may be a current of the purest air, is pale and easily broken; but let it be brought to the light and it becomes strong and of a natural color. If children were regarded as plants, and when old enough judiciously exposed to a moderately bright sky, they would acquire firmer constitutions.

Zoonic Batteries.—Many years ago we published an account of the resemblance of the brain to a Faraday's battery, and of some of the fibres proceeding from the inner plate to poles passing through

the coil of the pons Varolii. Besides the brain there are other galvanic arrangements for the functions of life, the principal of which are the lungs and the ganglionic system of nerves.

The apparatus for digestion is arranged for normal preparations, yet irregularities sometimes occur, such as the formation of sugar, which, entering the blood and passing off by the kidneys, produces diabetes; of hydrocholoric acid producing dyspepsia; lactic acid, rheumatism; lithic acid, gout, &c.

The theory advanced explains the phenomena of thermo-electricity, electro-magnetism, magneto-electricity, and double refraction, the consideration of which is deferred, as in this short essay it is only intended to make some remarks on a suggestion of Sir Humphrey Davy.

Light.—We talk of sound, not as a material agent, but as the name of a sensation produced by vibrations of the air. In like manner light can only be regarded as the name of a sensation effected by disturbance of equilibrium of the media through which it is perceived. The retina is formed by a concave daguerreotype plate, composed of nervous matter arranged in a beautiful mosaic. Anterior to and terminating on the plate there is a series of transparent fibres, which after leaving the eyeball are collected into a bundle which proceeds to the brain. Impressions on the concave plate are conveyed by this bundle, or optic nerve, as a message is conveyed to a distant spot by the electro-magnetic telegraph; but how that which is immaterial perceives the material cannot be conjectured. If the changes produced on the retina by surrounding objects occasion corresponding changes at the tubercula quadrigemina, what we have seen may be permanently recorded as the marks on the paper at the termination of a telegraph, or the corpora lutea on the ovarium.

When the sun appears above the horizon, the cells of the atmosphere and those of the earth are polarised by more direct exposure to the attraction of the immense mass of matter. The polarity is communicated along the ground to bodies in the shade, and the air becomes electrized in all directions. When parallel lines of polarised air cells fall on the cornea, the transparent media are similarly affected, and a picture is formed on the retina where the first circuit is completed. At the completion of the circuit, as at the poles of a battery, chemical changes occur which increase the polarity of the nerve cells, until the latter reach the tubercula quadrigemina, where the telegraphic lines terminate. Thus vision is affected by a double galvanic circuit, the application of which might be useful in art, as

Dolland improved optical instruments by imitating the structure of the crystalline lens.

When a lighted candle is brought into a dark room, the dobereiner battery of the wick polarises the air and the surfaces of the walls; the polarity passes to the ground and up the body to the eye, where the circuit is completed and vision effected as before.

When a beam of highly polarised air, which is arctic to the polarising body and ant-arctic to that on which it impinges, falls on a triangular prism, the glass becomes similarly affected, and in its turn polarises the air beyond it, but not in the same degree, for the lines of air cells are influenced by the unequal length of the glass, and by the size of the angles made by them and the outline of the prism. These unequally polarised lines of air cells or rays, which may be compared to what are called primary, secondary, tertiary, &c., currents of electricity, have different chemical effects. When ant-arctic, as at the blue portion of the spectrum and beyond it, there is analysis, as at the zinc pole of a battery moderately excited; when more arctic, as at the red, there is synthesis, as at the platinum pole; whereas, between the two, as at the yellow, the chemical effects are feeble, but there is more illuminating power, because the force of the surrounding air lines is greater, as iron placed within a coil makes the poles more energetic.

The cooling or heating effects of the poles of a moderately excited battery, may be illustrated by an experiment described in Davis's Manual of Magnetism. When thermometers are placed at the junctions of a bar of antimony with two bars of bismuth and electrized, the thermometer at the ant-arctic or zinc junction falls, and that at the arctic or platinum junction rises to a proportionably greater extent than the depression. It is presumed that the heating and cooling properties of the extreme ends of the spectrum, may be explained in the same way.

By intermittent attraction all the sensations are effected. The forms of solids are ascertained by touch, the qualities of fluids and vapor by taste and smell; by the undulations of the atmosphere we hear, and by its polarity we see; yet as far as matter is concerned, the falling of an apple explains them all. Irritation of the optic nerve produces only light, of a branch of the fifth pair only pain; each has its own function, and one will not supply the place of the other. Some nerves are chemists and architects to make proper selections from the raw material to construct and repair; some are watchmen

divided into those who give intelligence from without, and into those who give intelligence from within; and some obey the orders of the will. All are servants, who work together in such harmony that in health we are unconscious of their existence. But how it is that all the varieties of color proceed from the polarity of the air effected by the angles of elevation of the cells of the visible object; how it is that vibrations of the atmosphere, made in given time, produce all the varieties of tone which madden or soothe; or how it is that by the varieties of odor or taste, we can distinguish the useful from the noxious, is, and will remain a mystery.

We have endeavored to show that in all nature individuals are attracted to families, families to circles, circles to the state, the state to the union, the union to the world, and the world to the universe. There is not a word that we utter or a gesture we make which does not influence the harmony of our locality; and there is not a whisper of the wind or the falling of a leaf which does not influence the harmony of the surrounding elements. Without attraction the seed would not spring to cover the ground with green; the flower would not blossom or be covered with dew; the fruit would not ripen, and the tree would not wither. Without attraction the lungs might be filled with air, but it would afford no heat; the digestive organs might be supplied with food, but it would yield no nourishment, and the current of life would cease to flow. As there would be no birth there would be no death; there would be neither growth nor decay. If we have proved that light is attraction, then attraction, as is recorded, was the first-born of Heaven.

SUPPLEMENT.

Some portions of a copy of the preceding pages, when in manuscript, were missing, and not knowing how they might have been disposed of, the essay was published prematurely. I shall now attempt some further elucidation and modification of the theory, although conscious of the difficulty of making one part of it agree with another, and of avoiding errors attending the explanation of a subject to which my attention had not been turned for many years.

Note a.—In ordinary circumstances the cells of the air are all polarized in one direction, as the metallic cells of a magnet, or of an electrized wire or coil. When gravitation to the centre of the earth is diminished by a vacuum, the attraction of the air is increased; the lines of air cells, extending in every direction, are made tense by being drawn to the surrounding centres of gravity of the atmosphere, and the vacuum crossed from every point becomes a plenum. If, on the other hand, the air be compressed, the surrounding columns are made tense by increased attraction to the earth, and that which was diminished in volume, returns to its original size when the pressure is removed.

Note b.—The Columns of the Atmosphere compared to Magnets.—When the atmospheric arrangement is interrupted by a vacuum, the columns may be compared to broken magnets, the opposite poles of which attract each other. The polarity of the air cells presenting south poles, which are those beneath, the vacuum is reversed by being drawn upward by the attraction of the atmosphere; and the polarity of those above it, is also reversed by being drawn in the same direction. The upper portion of the inferior column becomes arctic, and the inferior portion of the upper column, antarctic. The volume of atmospheric air may be diminished by chemical changes producing attractions within the quantity with which we operate, but when diminished by pressure, south poles are presented at every point, and that which was compressed returns to its original size by the tension of the surrounding air. It is presumed that when two north poles of a metallic magnet are brought near each other, the atmospheric are arranged as the metallic cells, and that each of the north poles is attracted in every direction; but as the space between the magnets is trifling when compared with the miles of atmosphere on every side, these poles recede from each other and push the needles before them. When two south poles are brought near, it is also presumed

that the north poles are attracted in the same manner, and draw the needles after them.

Note c.—The centre of gravity of the earth is a point: the centre of gravity of the air is the segment of a circle. When a body becomes increased in weight, gravitation from every point *converges* to the former; whereas, when diminished, it *diverges* to the latter. When a beam of polarised air falls obliquely on a denser body, the latter is polarized towards the perpendicular; and when on a rarer body, from the perpendicular.

Note d.—Electrization may be compared to the elevation of a piston which requires force and time; de-electrization may be compared to the falling down of a piston, which is drawn down almost instantaneously by the weight of half the earth. In a person, electrization is imperceptible, but de-electrization or the returning stroke is sudden, and produces a shock.

Note e.—Cause of Electrical Rotation.—In addition to what has been related, we may suppose that the northern direction of the magnetic needle is the tendency of the atmosphere to the centre of gravity of the chain of elevations above the level of the sea, which extend nearly round the globe from Chili to Hindostan. Although the north poles of an electrized body are presented in every direction, there is a tendency to be arranged north and south, and by the effort to acquire this arrangement, rotation is forcibly effected.

Note f.—Magnetic curves may be compared to the jet of a fountain. When the force can no longer counteract gravitation, the water is drawn by the atmosphere on every side, and bends before proceeding in straight lines to the earth. The bar of iron, when placed vertically, may be compared to the column of water, and the effects of both on the atmosphere may be regarded as those produced by a denser or rarer body, as related.

Note g.—Aurora Borealis.—When a stratum of heated air passes from a lower to a higher latitude, the effect will be similar to that produced by a vacuum, as already described. The columns of the atmosphere will become tense by attraction to its line of gravity, and shoot upwards in irregular streamers.

Note h.—Temperature of the Planets.—The phenomena we have been considering, being produced by the reciprocal attractions of the earth and the air, if the atmospheres of Mercury and Venus be proportionately lighter than that surrounding the earth, the temperature may be lower than on our own planet, and if the distance of each of the other planets, from the sun, be compensated by a dense atmosphere, with or without, or a ring, they may be warmer.