passing through the whole three to give a shadow of the bones of the hand on another screen. I have advantageously employed a large screen, therefore, in which the crystals are even coarser than those previously used, and the thickness very much increased. By this means I have now no difficulty in seeing many of the deep structures of the body in movement.

Different Conditions of the Tube may be utilised for Different Effects.

Lately I have been trying to follow up Prof. J. J. Thomson's suggestion about there being different kinds of X-rays, in order to discover, if possible, whether a particular set of rays might be utilised for different tissues. Whether it be a matter of difference or intensity or difference in quality (as Prof. Thomson suggests), there can be no doubt with the tube in a certain condition the bones of the hand appear jet black on the fluorescent screen, while the soft tissues are scarcely visible. On the other hand, in a different condition of the tube the soft tissues are much more prominent and the bones faint. Following up this inquiry, I made a series of experiments by way of placing metal rings near the kathode, some of them earthed and all adjustable. I am quite aware others have placed rings of metal near the kathode, and described alterations in the tube which they have attributed to different causes. The sole object in my experiments was to afford an indication of alteration in a given condition of the tube. These experiments were so far successful, but I found much the same results could be obtained by using the discharge rods of the coil. The method adopted was, first, to heat the tube by means of a Bunsen burner until I got the exact condition required. The discharge rods were approximated until they cut out the focus tube, and then one was very slightly withdrawn until the tube again became fluorescent. The slightest alteration in the vacuum afterwards was immediately indicated by sparking across the gap. It need hardly be pointed out that an arrangement like Mr. Campbell Swinton's for correcting the vacuum by means of a magnet instead of heat would be an advantage if it could be applied to the ordinary focus tube. Once having selected the particular condition required, a small Bunsen burner below the tube may be so regulated as to give the necessary heat. By these means a particular condition of the tube may be kept up for a very long period without trouble. I have had it going on constantly in some instances for half-an-hour at a time with little or no apparent change in the appearance of the shadow of the tissues, and consequently had no difficulty in focusing the fluorescent screen on the ground glass of the camera, nor in photographing the screen with shadows of objects thereon.

Action upon Tissues and Fluorescent Screens.

Actions upon the tissues of the body have been recorded from several sources, and severe loss of skin and hair as a direct result of the application of the rays has been noted. Although I worked for months, it was only within the last few weeks that, having to place my hand near the tube, between it and the fluorescent screen, for long periods and several nights in succession, evidence of a dermatitis ensued. The hand looked as if it had been sunburned, and became red and swollen; there was afterwards shedding of epidermis and loss of hair. The severer effects remained for over a fortnight.

Another curious action on the tissues was noticed while photographing a fish. The apparatus used was the old form of German tube, and an induction coil with Tesla. After half-an-hour's exposure the back of the fish was covered with patches of phosphorescence, which remained for some hours afterwards.

It is usually considered that the action of the rays upon the potassium or barium screen is of very short duration. I have several times tried to see if the luminescence remained for any length of time after the current had been turned off, but could never record anything definite in this way. For reasons which need not be here entered upon, I had been experimenting with a view of putting the fluorescent screen into a particular condition for a period of time, and some metal objects were hung over the back of the screen to serve as a shadow. It was exposed to the effects of the rays for a quarter of an hour, and afterwards set aside where it was not acted upon by the daylight. The following evening I resumed my experiments, and found an image of the metal ring which had been used the previous night. The bluish colour was different inside and outside of the ring from that part of the screen which had been protected by the metal. The screen was immediately put past and examined for four nights in succession; each time, though less distinct, I could see the image, and it did not completely disappear for a week, during which time the screen was kept in the dark.

With regard to the action upon the tissues, I think it right to point out that there are at least two other forces at work—heat and electricity—and that while the former might not have much to do with the action on the skin, the latter might. In any case, however, the above-mentioned results were obtained after, and seem to have been the direct result of exposure to the action of forces in the region of the focus tube.

JOHN MACINTYRE.

JUMPING COCOONS.

THE curious movements of jumping beans have lately attracted some attention, though to style the spasmodic jerks of the beans jumps is to court disappointment. Some "jumping cocoons," described by Dr. D. Sharp in the *Entomologist*, were however, remarkably good athletes, for they could spring out of a small vessel, such as a tumbler, in which they were placed. These cocoons were from South Africa, but in spite of their exceptional gymnastic efficiency, Dr. Sharp hardened his heart and sacrificed them upon the altar of science, in the hope of discovering something unusual that would explain the powers of jumping. The cocoons looked like a piece of oval pottery, about five millimetres long, and having a rough surface. In each of the two investigated a pupa was found; the two were similar in every respect, and they no doubt belonged to the larvæ that made the cocoons. "This little pupa," says Dr. Sharp, "is shut up in a remarkably hard thick cocoon, and it has to get out. Nature has not provided it with caustic potash for the purpose, but has endowed it with a mechanism of complex perfection to accomplish this little object. On the front of the head it has a sharp chisel edge, and with this it has to cut through the pottery; contracting itself to the utmost in the posterior part of the cocoon, and retaining itself in this position by the hooks on the mobile part of the body, it is in a condition of elastic tension in consequence of the other side of the body being so differently formed and immobile; therefore, releasing the hold of the hooks, the pupa is discharged forwards, and the chisel piece strikes the front part of the cocoon; repeating this an enormous number of times a circle may be gradually inscribed on the inside of the far end of the cocoon, which gives way when sufficiently weakened, and the insect becomes free. In both the specimens the inside of the cocoon is about half-cut through; either this is done as the result of a prolonged series of wriggles, or of shocks such as I have described. It is by no means improbable that the early part of the performance is carving the groove by wriggling, the later part knocking it off by jumping against it." The pupa is thus a most interesting one to entomologists. The order of insects to which it belongs appears to be somewhat uncertain, but Dr. Sharp thinks it will prove to be an anomalous lepidopterous insect allied to Trichoptera, and possibly somewhere near to *Adela*.

MECHANICAL CONCEPTIONS OF ELECTRICAL PHENOMENA.[1]

MATTER AND MOTION.

UNTIL the middle of the present century the reigning physical philosophy held to the existence of what were called imponderables. The phenomena of heat were explained as due to an imponderable substance called "caloric," which ordinary matter could absorb and emit. A hot body was one which had absorbed an imponderable substance. It was, therefore, no heavier than before, but it possessed ability to do work proportional to the amount absorbed. Carnot's ideal engine was described by him in terms that imply the materiality of heat. Light was another imponderable substance maintained by Sir David Brewster as long as he lived. Electricity and magnetism were imponderable fluids, which, when allied with ordinary matter, endowed the latter with their peculiar qualities.

During the fifty years, from about 1820 to 1870, a somewhat different kind of explanation of physical events grew up. The

[1] Abridged from a lecture delivered before the Franklin Institute by Prof. A. E. Dolbear.

interest that was aroused by the discoveries in all the fields of physical science—in heat, electricity, magnetism and chemistry—by Faraday, Joule, Helmholtz and others, compelled a change of conceptions; for it was noticed that each special kind of phenomena was preceded by some other definite and known kind; as, for instance, that chemical action preceded electrical currents, that mechanical or electrical activity resulted from changing magnetism, and so on. As each kind of action was believed to be due to a special force, there were invented such terms as mechanical force, electrical force, magnetic, chemical and vital forces, and these were discovered to be convertible into one another, and the "doctrine of the correlation of the physical forces" became a common expression in philosophies of all sorts. By "convertible into one another" was meant that, whenever any given force appeared, it was at the expense of some other force; thus, in a battery, chemical force was changed into electrical force; in a magnet, electrical force was changed into magnetic force, and so on. The idea here was the *transformation of forces*, and *forces* were not so clearly defined that one could have a mechanical idea of just what had happened. That part of the philosophy was no clearer than that of the imponderables which had largely dropped out of mind. The terminology represented an advance in knowledge, but was lacking in lucidity, for no one knew what a force of any kind was.

The first to discover this and to repudiate it were the physiologists, who early announced their disbelief in a vital force, and their belief that all physiological activities were of purely physical and chemical origin, and that there was no need to assume any such thing as a vital force. Then came the discovery that chemical force, or affinity, had only an adventitious existence, and that, at absolute zero, there was no such activity. The discovery of, or rather the appreciation of, what is implied by the term *absolute zero*, and especially of the nature of heat itself, as expressed in the statement that heat is a mode of motion, dismissed another of the so-called forces as being a metaphysical agency having no real existence, though standing for phenomena needing further attention and explanation—and by explanation is meant *the presentation of the mechanical antecedents for a phenomenon, in so complete a way that no supplementary or unknown factors are necessary*. The train moves because the engine pulls it; the engine pulls because the steam pushes it. There is no more necessity for assuming a steam force between the steam and the engine, than for assuming an engine force between the engine and the train. All the processes are mechanical, and have to do only with ordinary matter and its conditions, from the coal pile to the moving freight, though there are many transformations of the forms of motion and of energy between the two extremes.

During the past thirty years, there has come into common use another term, unknown in any technical sense before that time, namely, *energy*. What was once called the conservation of force is now called the conservation of energy, and we now often hear of forms of energy. Thus, heat is said to be a form of energy, and the forms of energy are convertible into one another, as the so-called forces were formerly supposed to be transformable into one another. We are asked to consider gravitative energy, heat energy, mechanical energy, chemical energy, electrical energy. When we inquire what is meant by energy, we are informed that it means ability to do work, and that work is measurable as a pressure into a distance, and is specified as foot-pounds. A mass of matter moves because energy has been spent upon it and has acquired energy equal to the work done on it, and this is believed to hold true, no matter what the kind of energy was that moved it.

What a given amount of energy will do depends only upon its *form*; that is, the kind of motion that embodies it. The energy spent upon a stone thrown into the air, giving it translatory motion, would, if spent upon a tuning-fork, make it sound, but not move from its place; while if spent upon a top, would enable the latter to stand upon its point as easily as a person stands on his two feet, and to do other surprising things, which otherwise it could not do. One can, without difficulty, form a mechanical conception of the whole series without assuming imponderables, or fluids or forces. Mechanical motion only, by pressure, has been transferred in certain directions at certain rates. Suppose now that some one should suddenly come upon a spinning-top while it was standing upon its point, and, as its motion might not be visible, should cautiously touch it. It would bound away with surprising promptness, and, if he were not instructed in the mechanical principles involved, he might fairly well draw the conclusion that it was actuated by other than simple mechanical principles, and, for that reason, it would be difficult to persuade him that there was nothing essentially different in the body that appeared and acted thus, than in a stone thrown into the air; nevertheless, that statement would be the simple truth.

All of our experience, without a single exception, enforces the proposition that no body moves in any direction, or in any way, except when some other body *in contact* with it presses upon it. The action is direct. In a letter from Newton to his friend Bentley, he says: "That one body should act upon another through empty space, without the meditation of anything else by and through which their action and pressure may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it."

For mathematical purposes, it has sometimes been convenient to treat a problem as if one body could act upon another without any physical meaning between them; but such conception has no degree of rationality, and I know of no one who believes in that as a fact. If this be granted, then our philosophy agrees with our experience, and every body moves because it is pushed, and the mechanical antecedent of every kind of phenomenon is to be looked for in some adjacent body possessing energy—that is, the ability to push or produce pressure.

It must not be forgotten that energy is not a simple factor, but is always a product of two factors: a mass with a velocity, a mass with a temperature, a quantity of electricity into a pressure, and so on. One may sometimes meet the statement that matter and energy are the two realities; both are spoken of as entities. It is much more philosophical to speak of matter and motion, for in the absence of motion there is no energy, and the energy varies with the amount of motion; and furthermore, to understand any manifestation of energy one must inquire what kind of motion is involved. It is now too late to stop with energy as a final factor in any phenomenon; and the *form of motion* which embodies the energy is the factor that determines *what* happens, as distinguished from how *much* happens. Here, then, are to be found the distinctions which have heretofore been called forces; here is embodied the proof that direct pressure of one body upon another is what causes the latter to move, and that the direction of movement depends on the point of application, with reference to the centre of mass.

ACTION AT A DISTANCE.

Let us now look at the other term in the product we call energy, namely, the substance moving, sometimes called matter or mass. It has been mentioned that the idea of a medium filling space was present with Newton, but his gravitation problem did not require that he should consider other factors than masses and distances. The law of gravitation as considered by him was: Every particle of matter attracts every other particle of matter with a stress which is proportional to the product of their masses, and inversely to the squares of the distance between them. Here we are concerned only with the statement that every particle of matter attracts every other particle of matter. Everything then that possesses gravitative attraction is matter in the sense in which that term is used in this law. If there be any other substance in the universe that is not thus subject to gravitation, then it is improper to call it matter.

We are now assured that there is something else in the universe which has no gravitative property at all, namely, the ether. It was first imagined in order to account for the phenomena of light, which was observed to take about eight minutes to come from the sun to the earth. Then Young applied the wave theory to the explanation of polarisation and other phenomena; and, in 1851, Foucault proved experimentally that the velocity of light was less in water than in air, as it should be if the wave theory be true, and this has been considered a crucial experiment which took away the last hope for the corpuscular theory and demonstrated the existence of the ether as a space-filling medium capable of transmitting light waves known to have a velocity of 186,300 miles per second. It was called the luminiferous ether, to distinguish it from other ethers which had also been imagined, such as electric ether for electric phenomena, magnetic ether for magnetic phenomena, and so on—as many ethers as there were different kinds of phenomena to be explained.

It was Faraday who put a stop to the invention of ethers, by suggesting that the so-called luminiferous ether might be the one concerned in all the different phenomena, and who pointed out that the arrangement of iron filings about a magnet was indicative of the direction of the stresses in the ether. This suggestion did not meet the approval of the mathematical physicists of his day, for it necessitated the abandonment of the conceptions they had worked with, as well as the terminology which had been employed, and made it needful to reconstruct all their work to make it intelligible.

It has turned out that Faraday's mechanical conceptions were right. Every one now knows of Maxwell's work, which was to start with Faraday's conceptions as to magnetic phenomena, and follow them out to their logical conclusions, applying them to molecules and their reactions upon the ether. Thus he was led to conclude that light was an electro-magnetic phenomenon; that is, that the waves which constitute light and waves produced by changing magnetism were identical in their nature, were in the same medium, travelled with same velocity, were capable of refraction, and so on. Now, that all this is a matter of common knowledge to-day, it is curious to look back no further than ten years. Maxwell's conclusions were adopted by scarcely a physicist in the world. Although it was known that inductive action travelled with finite velocity in space, and that an electro-magnet would affect the space about it practically inversely as the square of the distance, and that such phenomena as are involved in telephonic induction between circuits could have no other meaning than the one assigned by Maxwell, yet nearly all the physicists failed to form the only conception of it that was possible, and waited for Hertz to devise apparatus for producing interference before they grasped it. It was even then so new, to some, that it was proclaimed to be a demonstration of the existence of the ether itself, as well as a method of producing waves short enough to enable one to notice interference phenomena. It is obvious that Hertz himself must have had the mechanics of wave motion plainly in mind, or he would not have planned such experiments. The outcome of it all is, that we now have experimental proof, as well as theoretical reason, for believing that the ether, once called luminiferous, is concerned in all electric and magnetic phenomena, and that waves set up in it by electro-magnetic actions are capable of being reflected, refracted, polarised, and twisted, the same as ordinary light waves can be, and that the same laws are applicable to both

Phenomena of the ether are so utterly unlike the phenomena of ordinary matter that it is apparent the name matter ought not to be applied to this medium. Furthermore, it is also apparent that all attempts to describe the properties of the ether in the terms applicable to matter will be misleading. Here is a substance which, experimentally, shows itself to be illimitable, continuous, homogeneous, isotropic, non-atomic, frictionless, incompressible, incapable of transforming its own energy, gravitationless, and insensible to all nerves, compared with what is limited, discontinuous, heterogeneous, eolotropic, atomic, frictionable, compressible, capable of transforming energy, gravitative, and upon which all nerve action depends. Are not these distinctions wide enough to make one beware of thinking of them and describing their phenomena in the same terms?

ANTECEDENTS OF ELECTRICAL PHENOMENA.

When we would give a complete explanation of the phenomena exhibited by, say, a heated body, we need to inquire as to the antecedents of the manifestation, and also its consequents. Where and how did it get its heat? Where and how did it lose it? When we know every step of those processes, we know all there is to learn about them. Let us undertake the same thing for some electrical phenomena.

First, under what circumstances do electrical phenomena arise? (1) *Mechanical*, as when two different kinds of matter are subject to friction. (2) *Thermal*, as when two substances in molecular contact are heated at the junction. (3) *Magnetic*, as when any conductor is in a changing magnetic field. (4) *Chemical*, as when a metal is being dissolved in any solution. (5) *Physiological*, as when a muscle contracts. Each of these has several varieties, and changes may be rung on combinations of them, as when mechanical and magnetic conditions interact.

If one confines his attention to the only variable factor in the energy in all these cases, and traces out in each just what happens, he will have only motions of one sort or another, at one rate or another, and there is nothing mysterious which enters into the processes.

We will turn now to how electricity manifests itself, and what it can do. It may be well to point out at the outset what has occasionally been stated, but which, in my judgment, has not received the philosophical attention it deserves, namely, that electrical phenomena are reversible, that is, any kind of a physical process which is capable of producing electricity, electricity is itself able to produce. Thus, to name a few: If mechanical motion develops electricity, electricity will produce mechanical motion; the movement of a pith ball is a simple case. If chemical action can produce it, it will produce chemical action, as in the decomposition of water and electro-plating. As heat may be its antecedent, so will it produce heat. If magnetism be an antecedent factor, magnetism may be its product. What is called induction may give rise to it in an adjacent conductor, and, likewise, induction may be its effect.

Suppose we have a series of active machines. An arc lamp, radiating light waves, gets its energy from the wire which is heated, which in turn gets its energy from the electric current, that from a dynamo, the dynamo from a steam engine, that from a furnace and the chemical actions going on in it. Let us call the chemical actions A, the furnace B, the engine C, the dynamo D, the electric lamp E, the ether waves F.

—Chemical energy (A) — Furnace (B) — Steam engine (C) — Dynamo (D) — Arc lamp (E) — Ether waves (F) →

The product of the chemical action is molecular motion, called heat in the furnace. The product of the heat is mechanical motion in the engine. The product of the mechanical motion is electricity in the dynamo. The product of the electrical current in the lamp is light waves in the ether. Nobody hesitates an instant to speak of light waves as forms of motion, for they are described as undulations in the ether at right angles to the direction of the radiation. No one hesitates for an instant to speak of the heat as being molecular motion, nor of the motions of the engine as being mechanical; but when we come to the product of the dynamo, which we call electricity, behold, nearly every one says, not that he does not know what it is, but that no one knows! Does any one venture to say he does not know what heat is, because he cannot describe in detail just what goes on in a heated body as it might be described by one who saw with a microscope the movements of the molecules? Let us go back for a moment to the proposition stated early in the address, namely, that if any body of any magnitude moves, it is because some other body in motion and in contact with it has imparted its motion by mechanical pressure. Therefore, the ether waves at F imply continuous motions of some sort from A to F. That they are all motions of ordinary matter from A to E is obvious, because continuous matter is essential for the maintenance of the actions. At E the motions are handed over to the ether, and they are radiated away as light waves.

ROTATION IN ELECTRICAL CONDUCTORS.

A puzzling electrical phenomena has been what has been called its duality—states which are spoken of as positive and negative. Thus, we speak of the positive plate of a battery and the negative pole of a dynamo, and another troublesome condition to idealise has been, how it could be that, in an electric circuit, there could be as much energy at the most remote part as at the source. But, if one will take a limp rope, eight or ten feet long, tie its ends together, and then begin to twist it at any point, he will see the twist move in a right-handed spiral on the one hand, and in a left-handed spiral on the other, and each may be traced quite round the circuit; so there will be as much twist, as much motion, and as much energy in one part of the rope as in any other; and if one chooses to call the right-handed twist positive, and the left-handed twist negative, he will have the mechanical phenomenon of energy distribution and the terminology analogous to what they are in an electric circuit. So far, there is no trouble; but one can see the rope as a whole twisting, and nothing can be seen in an electric conductor. Are not the cases more dissimilar than the mechanical analogy would make them seem to be?

Are there any phenomena which imply that rotation is going on in an electrical conductor? There are. An electric arc, which is a current in the air, and is, therefore, less constrained than it is in a conductor, rotates. Especially marked is this when in front of the pole of a magnet; but the rotation may be noticed in an ordinary arc by looking at it with a stroboscopic disc, rotated so as to make the light to the eye intermittent at the rate of four or five hundred per second. A ray of plane polarised light, parallel with a wire conveying a current, has its plane of vibration twisted to the right or left, as the current goes one way or the other through the wire, and to a degree that depends upon the distance it travels; not only that, but if the ray be sent, by reflection, back through the same field, it is twisted as much more—a phenomenon which convinces one that rotation is going on in the space through which the ray travels. If the ether through which the ray be sent were simply warped or in some static stress, the ray, after reflection, would be brought back to its original plane, which is not the case. This rotation in the ether is produced by what is going on in the wire. The ether waves called light are interpreted to imply that molecules originate them by their vibrations, and that there are as many ether waves per second as of molecular vibrations per second. In like manner, the implication is the same, that if there be rotations in the ether they must be produced by molecular rotation, and there must be as many rotations per second in the ether as there are molecular rotations that produce them. The space about a wire carrying a current is often pictured as filled with whorls indicating this motion, and one must picture to himself, not the wire as a whole rotating, but each individual molecule independently. But one is aware that the molecules of a conductor are practically in contact with each other, and that if one for any reason rotates, the next one to it would, from frictional action, cause the one it touched to rotate in the opposite direction, whereas the evidence goes to show that all rotation is in the same direction.

How can this be explained mechanically? Recall the kind of action that constitutes heat, that it is not translatory action in any degree, but vibratory, in the sense of a change of form of an elastic body, and this, too, of the atoms that make up the molecules of whatever sort. Each atom is so far independent of every other atom in the molecule that it can vibrate in this way, else it could not be heated. The greater the amplitude of vibration, the more free space to move in, and continuous contact of atoms is incompatible with the mechanics of heat. There must, therefore, be impact and freedom alternating with each other in all degrees in a heated body. If, in any way, the atoms themselves *were* made to rotate, their heat impacts not only would restrain the rotations, but the energy also of the rotation motion would increase the vibrations; that is, the heat would be correspondingly increased, which is what happens always when an electric current is in a conductor. It appears that the colder a body is the less electric resistance it has, and the indications are that at absolute zero there is no resistance; that is, impacts do not retard rotation, but it is also apparent that any current sent through a conductor at that temperature would at once heat it. This is the same as saying that an electric current could not be sent through a conductor at absolute zero.

MATERIAL CONDITIONS OF ELECTRICAL MANIFESTATIONS.

So far, mechanical conceptions are in accordance with electrical phenomena, but there are several others yet to be noted. I have spoken of electrical phenomena as molecular or atomic phenomena, and there is one more in that category which is well enough known, and which is so important and suggestive, that I wonder its significance has not been seen by those who have sought to interpret electrical phenomena. I refer to the fact that electricity cannot be transmitted through a vacuum. An electric arc begins to spread out as the density of the air decreases, and presently it is extinguished. An induction spark that will jump two or three feet in air cannot be made to bridge the tenth of an inch in an ordinary vacuum. A vacuum is a perfect non-conductor of electricity. Is there more than one possible interpretation to this, namely, that electricity is fundamentally a molecular and atomic phenomenon, and in the absence of molecules cannot exist? One may say: "Electrical *action* is not hindered by a vacuum," which is true, but has quite another interpretation than the implication that electricity is an ether phenomenon. The heat of the sun in some way gets to the earth, but what takes place in the ether is not heat conduction. There is no heat in space, and no one is at liberty to say, or to think, that there can be heat in the absence of matter.

When heat has been transformed into ether waves it is no longer heat, call it by what name one will. Formerly such waves were called heat waves; no one, properly informed, does that now. In like manner, if electrical motions or conditions in matter be transferred, no matter how, it is no longer proper to speak of such transformed motions or conditions as electricity. Thus, if electrical energy be transformed into heat, no one thinks of speaking of the latter as electrical. If the electrical energy be transformed into mechanical of any sort, no one thinks of calling the latter electrical because of its antecedent. If electrical motions be transformed into ether actions of any kind, why should we continue to speak of the transformed motions or energy as being electrical? Electricity may be the antecedent, in the same sense as mechanical motion of a bullet may be the antecedent of the heat developed when the latter strikes the target; and if it be granted that a vacuum is a perfect non-conductor of electricity, then it is manifestly improper to speak of any phenomenon in the ether as an electrical phenomenon. It is from the failure to make this distinction that most of the trouble has come in thinking on this subject. Some have given all their attention to what goes on in matter, and have called that electricity; others have given their attention to what goes on in the ether, and have called that electricity, and some have considered both as being the same thing, and have been confounded.

RELATION BETWEEN AN ELECTRIFIED BODY AND THE ETHER.

Let us consider what is the relation between an electrified body and the ether about it.

When a body is electrified, the latter at the same time creates an ether stress about it, which is called an electric field. The ether stress may be considered as a warp in the distribution of the energy about the body, by the new positions given to the molecules by the process of electrification. I have already said that the evidence from other sources is that atoms, rather than molecules, in larger masses, are what affect the ether. One needs to inquire for what knowledge we have as to the constitution of matter or of atoms. There is only one hypothesis to-day that has any degree of probability; that is the vortex-ring theory, which describes an atom as being a vortex ring of ether, in the ether. It possesses a definite amount of energy in virtue of the motion which constitutes it, and this motion differentiates it from the surrounding ether, giving it dimensions, elasticity, momentum, and the possibility of translatory, rotary, vibratory motions and combinations of them. Without going further into this, it is sufficient, for a mechanical conception, that one should have so much in mind, as it will vastly help in forming mechanical conceptions of reactions between atoms and the ether. An exchange of energy between such an atom and the ether is not an exchange between different kinds of things, but between different conditions of the same thing. Next, it should be remembered that all the elements are magnetic in some degree. This means that they are themselves magnets, and every magnet has a magnetic field unlimited in extent, which can almost be regarded as a part of itself. If a magnet of any size be moved, its field is moved with it, and if in any way the magnetism be increased or diminished, the field changes correspondingly.

Assume a straight bar electro-magnet in circuit, so that a current can be made intermittent, say, once a second. When the circuit is closed and the magnet is made, the field at once is formed and travels outwards at the rate of 186,000 miles per second. When the current stops, the field adjacent is destroyed. Another closure develops the field again, which, like the ether, travels outwards; and so there may be formed a series of waves in the ether, each 186,000 miles long, with an electro-magnetic antecedent. If the circuit were closed ten times a second, the waves would be 18,600 miles long; if 186,000 times a second, they would be but one mile long. If 400 million of millions times a second, they would be but the forty-thousandth of an inch long, and would then affect the eye, and we should call them light waves, but the latter would not differ from the first wave in any particular except in length. As it is proved that such electro-magnetic waves have all the characteristics of light, it follows that they must originate with electro-magnetic action, that is, in the changing magnetism of a magnetic body. This makes it needful to assume that the atoms which originate waves are magnets, as they are experimentally found to be. But how can a magnet, not subject to a varying current, change its magnetic field? The strength or density of a magnetic field depends upon the form of the magnet. When the poles are near together, the field is densest; when the magnet is bent back to a straight bar, the field is rarest or weakest, and a change in the form of the magnet from a U-form to a straight bar would result in a change of the magnetic field within its greatest limits. A few turns of wire wound about the poles of an ordinary U-magnet, and connected to an ordinary magnetic telephone, will enable one, listening to the latter, to hear the pitch of the former loudly reproduced when the magnet is struck like a tuning-fork so as to vibrate. This shows that the field of the magnet changes at the same rate as the vibrations.

Assume that the magnet becomes smaller and smaller until it is of the dimensions of an atom, say, for an approximation, the fifty-millionth of an inch. It would still have its field; it would still be elastic and capable of vibration, but at an enormously rapid rate; but its vibration would change its field in the same way, and so there would be formed those waves in the ether, which, because they are so short that they can affect he eye, we call light. The mechanical conceptions are legiimate, because based upon experiments having ranges through nearly the whole gamut as waves in ether.

The idea implies that every atom has what may be loosely called an electro-magnetic grip upon the whole of the ether, and any change in the former brings some change in the latter.

What I would like to emphasise is, that the action in the ether s not electric action, but more properly the result of electro-magnetic action. Whatever name be given to it, and however it comes about, there is no good reason for calling any kind of an ether action electrical.

Electric action, like magnetic action, begins and ends in matter. It is subject to transformations into thermal and mechanical actions, also into ether stress—right-handed or left-handed—which, in turn, can similarly affect other matter, but with opposite polarities.

In his "Modern Views of Electricity," Prof. O. J. Lodge warns us, in a way I quite approve, that perhaps, after all, there is no such *thing* as electricity—that electrification and electric energy may be terms to be kept; but if electricity as a term be held to imply a force, a fluid, an imponderable, or a thing which could be described by some one who knew enough, then it has no degree of probability, for spinning atomic magnets seem capable of developing all the electrical phenomena we meet.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The election to the Professorship of Geology, vacant through the death of the late Prof. Green, will take place in Hilary Term, 1897. Candidates are requested to send their applications, together with such evidence of their qualifications as they may desire, to the Registrar of the University on or before February 1, 1897. The Professor is required to lecture in Geology and Palæontology in two of the three University Terms, and to take charge of the Geological and Palæontological collections belonging to the University. He is entitled to receive £400 per annum from the University chest, which sum may be augmented to not less than £700 nor more than £900 per annum, if the University revenues permit, and unless provision for the payment of a corresponding amount shall have been made from some other source. Mr. W. B. Prowse is at present acting as Deputy Professor.

Mr. W. Ramsden has been elected Sheppard Medical Fellow of Pembroke College.

The Burdett-Coutts Scholarship will not be awarded for 1896, the only candidate who presented himself having withdrawn before the close of the examination.

Prof. E. B. Poulton has recently returned to Oxford from a visit to America.

The following have been approved by Convocation as Examiners in Medicine for 1897, 1898, and 1899:—1. For the first M.B. Examination: Prof. A. Macalister (Cambridge), in Human Anatomy. 2. For the second M.B. Examination: Prof. W. MacEwen (Glasgow), in Surgery. Dr. David Berry Hart (Edin.), in Midwifery.

The Junior Scientific Club held its first meeting this term on Friday, November 6, when Mr. D. Meinertzhagen (New Coll.) gave an interesting account of "Hawks and Hawking," and Mr. W. Garstang read a paper entitled, "The Ancestry of the Vertebrata as a Physiological Problem." The Committee for the present term is composed as follows:—President: H. P. Stevens. Treasurer: A. W. Brown. Secretaries: E. H. Hunt and I. B. Billinghurst. Editors: R. A. Buddicum, A. E. Boycott, A. C. Pilkington and A. R. Wilson.

CAMBRIDGE.—An election to an Isaac Newton Studentship of 200*l.* a year for three years will be held in the Lent Term, 1897. The student is to devote himself to research in Cambridge in astronomy or physical optics. Candidates must be Cambridge B.A.s under the age of twenty-five on January 1, 1897. Applications are to be sent to the Vice-Chancellor not later than January 25.

Mr. S. F. Harmer has been appointed Chairman of Examiners for the Natural Sciences Tripos, 1897.

The Sedgwick Memorial Museum Syndicate propose that the site granted by the University near the new museums should be abandoned, and that a new site on the ground formerly belonging to Downing College, and recently acquired by the University, should be assigned instead. Some difference of opinion is likely to arise on the expediency of the proposal, which will involve the preparation of new plans and further delay.

The following awards in Natural Science were made at Trinity College on November 14: Major Scholarship (80*l.*), O. W. Richardson, Batley School; Minor Scholarship (50*l.*), G. Barger, High School, The Hague; Sizarship, R. E. Robinson, Newcastle (Staffs.) School; Exhibitions (40*l.*), H. Gaskell (Rugby), G. Savory (Harrow), and E. E. Walker (Bradford).

DR. PHILIPP LENARD has removed from Aachen, to take up a professorship of theoretical physics in the University of Heidelberg.

MR. THOMAS TICKLE, of the School of Pharmacy, has been elected to the Salters' Company Research Fellowship in Chemistry, tenable in the Research Laboratory of the Pharmaceutical Society.

WITH reference to the note on the University College, Bristol, in last week's NATURE (p. 46) we are informed that the Bristol Town Council has altogether given the College 4000*l.* The Council gave 2000*l.* towards the Engineering wing, just opened by Mr. Wolfe Barry, and has recently granted another 2000*l.* towards the capital sum of 10,000*l.* which the College authorities are trying to raise.

A RECENT law restored to the various French University centres the title of University, together with some measure of self-government; whereas since the time of Napoleon they had simply been sections of one University, and with the title of faculties. The *Times* correspondent at Paris states that arrangements have been made to celebrate the opening of term under the new system to-day by a gathering of professors and students, over which M. Faure will preside.

AT the distribution of prizes at the Barking Technical School, by the Countess of Warwick, on November 11, an address on the technical education movement was delivered by Prof. R. Meldola, F.R.S., of the Technical Instruction Committee of the Essex County Council. In the course of his remarks, the speaker deplored the line of action so generally followed throughout Essex, as well as in other counties, and which resulted in the greater part of the fund at their disposal being frittered away in small efforts at evening instruction. The main portion of the address was devoted to pointing out the true position of evening work in the scheme of technical education. It was contended that this kind of instruction, although to a certain extent useful, and even necessary, was not in itself more than an aid to true technical education, and could not, unless crowned by higher efforts, be of any use to the country at large as a means of enabling us to compete successfully with our foreign rivals in manufacturing and agricultural industries. For this reason the speaker, while admitting the good work which had been hitherto carried on at Barking, felt bound to express his regret that so much of the resources available for technical instruction had been used up in the formation of classes for cookery, ambulance, dressmaking, and other subjects, which, in his opinion, should have been subsidised from other sources, or else taught in schools. Reference was made to the recent correspondence in the papers on the state of technical education on the continent as compared with that in this country, and figures were quoted showing the relative amount of endowment of technical high schools and polytechnics in Germany and Switzerland as compared with those in England. The speaker described from personal experience, and in high terms of praise, the zeal and energy with which men engaged all day in arduous work will come to evening classes to improve their knowledge of scientific principles. He felt sure, however, that such men were sensible enough to see how hopeless it was to make headway against the expert knowledge of highly-trained and specialised students from the German schools, who devote