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ORDINARY MEETING.*

PROFESSOR H. L. ORCHARD, M.A., B.Sc., IN THE CHAIR.

The Minutes of he last Meeting were read and confirmed; the Chairman then called on Mr. Slater to read his paper.

LIFE AS COMPARED WITH THE PHYSICAL FORCES. By J. W. SLATER, Esq., F.C.S., F.E.S.

THE question is often asked, "What is Life?" and to this inquiry the most profound thinker and the most careless and superficial dullard, whether of the "classes" or the "masses," is equally unable to give a reply. We may, indeed, heap up words which merely darken counsel and obscure what they profess to explain.

2. We are often asked whether life is a principle or an agency like the so-called "physical forces," or as they are now more generally named, "forms of energy."

3. Is life at all comparable to heat, to light, to electricity, to magnetism, to chemical, or to mechanical action? Some persons tell us that all these forces are merely certain modes of motion acting under peculiar conditions upon matter. If this is the case, and if life is one of them, then a living organism also is merely matter set in motion. Let us examine this doctrine.

4. The first great difference which we can recognize between life and the physical forces is this; we can measure any of

* February 20th, 1893.

these physical forces by their manifestations; but we cannot measure life by its manifestations. We can measure light with great accuracy. We can compare one source of light with another, and thus ascertain the luminous power of the sun, of Sirius, of an arc-lamp, a glass lamp, a gas burner, a candle, or an aurora borealis. We can show how many candles we should have to group together for their united radiance to equal that of the sun.

5. In like manner we can measure heat. We can find the temperature required for melting any of the metals or for boiling or evaporating away any liquid. We can determine the quantity of heat which can be obtained, for instance, by burning one ton of coal, of any determined composition.

6. We can measure the power of a magnet, or of the electric current produced by a dynamo, or by a galvanic battery of some known construction. Most easily of all we can measure mechanical power, or the motion which it produces.

7. But can we make any similar determination or measurement with life? Can we, for instance, say whether there is more or less life in a child or in a grown man, in a microbe or in a whale, in an ox or in an oak tree? Some of these, and of many similar questions which might be framed, strike us at once not merely as unanswerable, but as absurd.

8. You might, perhaps, say that there is more life in a man than in a hedgehog. The man will live longer, travel faster and further, and exert more power in various directions than can the hedgehog. He is a greater weight of living matter —a point which some people take as a standard. But give the man a score of Spanish flies, and he will die in torment. Give the hedgehog a similar dose and he will eat them without injury, and in his manner he will ask for more. In short, his life resists and overcomes an agency which destroys the life of man.

9. We might, perhaps, fancy so swift, powerful, and heavy an animal as the African buffalo must contain more life than a man. Not so; let man and buffalo be each bitten by a Tsetse fly. The buffalo will shortly perish, but the man will experience no more inconvenience than he would from the bite of a gnat.

10. Or again we might think that the quantity of life in an ox would be almost immeasurably greater than that in the spore of a microbe. Yet the spore will resist degrees of cold and heat much more than sufficient to kill the ox.

11. We see further difficulty in finding a measure for life if

we compare a mammal with a bird on the one hand and with a reptile on the other. Both these two live longer than mammalia. But whilst the bird breathes more rapidly and abundantly than the beast, whilst its blood circulates more rapidly and has a higher temperature than that of the beast, the reptile deviates in the opposite direction. The bird, it may be said, differs from a lump of stone more widely than does the beast, but the reptile differs less. What then is the standard according to which life could be measured?

12. A further difference between life and the physical forces, or modes of energy, is that we can convert the latter into each other. But we can effect no such transformations with life. Let us take an instance; a lump of coal contains, stored up, a quantity in proportion to its weight and its quality. If we burn it, this chemical energy is converted into heat. If we allow this heat to act upon the boiler of a steam engine the heat is converted into mechanical motion. These transformations are not arbitrary in their quantity but quite definite.

13. We may go further: if we use the mechanical power to make a coil of wire revolve between the two poles of a magnet the mechanical power is thus transformed into electricity, which again by certain arrangements can be made to appear as light (arc-light). Similar transformations backwards and forwards can be effected in different directions. We can convert heat directly into light. We can transform motion into heat as in the well-known process which ensues if the axle of a wheel in quick rotation is not supplied with any lubricant to reduce the friction. We convert mechanical power into electricity by rubbing a piece of glass or amber with rough dry silk—the manner in which electricity was first observed.

14. But can we transform any one of these forces or agencies —call them what we please—into life? No; life as we know it, can certainly exist only between certain limits of temperature, probably at the outside between $-100°$ to $+300°$ Fahrenheit. If we reduce the temperature still lower all forms of life die out as do most long before reaching this lower limit. If we heat living beings too strongly they also cease to exist. Some of the spores of microscopic organisms can resist a temperature exceeding that of boiling water. But very few of the larger and more highly developed animals and plants can bear a heat exceeding 120° or below 10° Fahrenheit.

15. Yet this fact that life can exist only between certain limits of temperature gives us no right to infer that heat *is* life. We may heat matter—even organic matter—to the most varied degrees, but if we thoroughly exclude all germs of life it remains inert and dead. The manifestations of life and of heat touch each other, but they are not mutually convertible. Others—especially quacks—tell us that electricity is life, but they fail to produce any decisive evidence in support of their hypothesis.

16. It is again said that light is life. In reply, we may be content to point out that multitudes of living beings, both plants and animals, exist and multiply in absolute darkness, for which, indeed, they seem especially adapted.

17. We come now to a capital distinction. We may start heat, light, or motion afresh where nothing of the kind has previously existed. We may descend to the furthest accessible point in the Blue John Cavern at Castleton, where no light has penetrated since the present order of things took its rise. If we have provided ourselves with a box of matches and a candle we shall find it quite as easy to strike a match and to light a candle as on the surface of the earth, where the sun's light visits us every day (except in London). Or let us find some place where no electric current is traceable. Yet by rubbing a stick of sealing-wax or a cake of gutta-percha with silk, or catskin, we obtain electric sparks. In short, any of the physical forces can, so to speak, be started afresh.

18. How is it with life? Our great anatomist Hunter said, "all life comes from the egg" (*omne vivum ex ovo*), or in other words, there is no life without pre-existing life, be it in the form of egg, seed, or spore.

19. Experiments have been made without end to obtain life from inanimate matter. Virgil gives a receipt for creating a swarm of bees from the carcase of a bull. Insects generally were supposed to arise spontaneously out of dust, water, or refuse of any kind. It will scarcely be believed that good old Rösel, Jan Swammerdam and other naturalists of the old time had to show how moths, butterflies, beetles, bees, etc., were produced from eggs, to trace these creatures through their successive stages of growth and development, and to prove that they no more originate spontaneously than do horses or men. Errors die hard. When it was shown that insects are procreated by antecedent insects the believers in spontaneous generation retreated to more obscure regions. It

was urged that infusoria and microbia were self-begotten. The experiments made in this direction by Pouchet and others seemed at times to be successful; but on closer examination some flaw was always present. The air is not free from the spores of microscopic vegetation, nor even from the ova of minute animalcules. The surfaces of the apparatus used in such experiments, glasses, forceps, stirring rods, etc., are coated with them; the water and even the mercury used are not free from life. Pasteur and Tyndall have made many experiments with every precaution, and have again and again found Hunter's law verified—"no life without antecedent life."

20. The trial is being daily made in commerce on a gigantic scale. The Australian mutton, heated for a sufficient time to a temperature high enough to destroy the germs of life, at once plunged into tins similarly heated and at once soldered up, remains sound,—that is lifeless. In a few rare cases where such tinned meats have been found bad on opening, it has appeared that there was some little flaw or chink in the metal or the soldering through which air might enter. And where air does so enter it carries along with it the germs of life.

21. The experimentalists who have endeavoured to originate life afresh have all been guilty of an error in principle, which would have vitiated their results even if apparently successful. They operated upon animal and vegetable matter, milk, blood, juices of meat, decoctions of hay, etc. Now all these substances presuppose the existence of life. They have never fairly attempted to originate life from mineral matters! Hence their most skilful experiments have been in principle null and void. Before we can show the origin of life we must be able to produce it in matter which is not merely lifeless, but which is not a product of life, and which as far as we know has never been quickened. No attempts in this direction are recorded in the scientific journals. I must confess that when a youth I spent some time in experiments of this kind. I am now by no means disposed to renew the attempts. If man were able to call into existence some being which has no place in nature, it might prove to be the germ of some pestilence more dreadful than any yet known.

22. There are persons who tell us that if we can only bring protoplasm into spontaneous motion the great problem of life will have been solved. *If!* we have long ago been told

that there is much virtue in an *if*. Those who make this suggestion merely show their want of acquaintance with protoplasm. This substance has never yet been found except in plants or animals, living or dead. Search the inorganic world through and you will not find it. The chief source for it is in a fungus known as *Ethalium septicum*, growing on the heaps of spent bark thrown out from tanneries. It is not a simple substance. It does not consist chiefly of albumen or gelatine. It is composed of no fewer than forty-five constituents, namely, plastine, myosine, peptone, peptonoid, pepsine, mecleine, letheine, guanine, sarcene, xanthene, ammonium carbonate, paracholesterine, traces of cholesterine, ethalium resin, a yellow colouring matter, glycogen, a non-reductive sugar, oleic, stearic, palmitic, butyric and carbonic acids, glycerides and paraglycerides of the fatty acids, calcium stearate, palmitate, oleate, lactate, oxalate, acetate, formiate, phosphate, carbonate, and sulphate, magnesium and potassium phosphate, sodium chloride, iron (in some unknown state), and water! How are all these substances (many of which are in themselves very complex and are to be obtained only from pre-existing plants and animals) to come together and to combine? By chance? Protoplasm is, in fact, not the cause but a consequence of life. And when we have it before us how are we to set up in it those molecular motions which we recognise in living beings? As a half-way step towards animation I have taken the unimpregnated eggs of female moths and have exposed them to different temperatures, to different rays of light, to feeble electric currents, to the action of magnets, to gentle mechanical movements. But all these methods proved vain The eggs dried up and became decomposed, and on microscopic examination they were found not to have taken the slightest step towards life.

23. We are sometimes told that at one time men of science doubted the possibility of forming organic compounds artificially until Woehler produced urea from dead matter, and that we may, perhaps, some day be able to manufacture not merely organic matter but actual organisms. It will be soon enough to consider this case when it shall have arisen. Up to the present day chemists have produced artificially secondary products, excretions, pigments, results of decomposition; but they have never obtained any of the primary compounds in which life seems to inhere. Much less have they produced organisms, organised structures, of whatever

degree. When they shall have done this.—when they can show us, in the receiver, a globule which assimilates outside matter, grows, displays irritability, reproduces itself, and dies, their claims may be sure of a fair examination. But it is surely unphilosophical to take into account evidence which has never yet been brought forward.

24. In fine the more we observe, experiment, and study, the more we are disposed to conclude with Moses, Hunter, and Darwin—who all substantially agree on this point—that life has not sprung up spontaneously on the earth, but that it has been originated by a Higher Power. We may safely say that this power cannot have been the god of Comte and the Positivists, Human Nature in the abstract.

Discussion.

Dr. R. C. Shettle.—I think that Mr. Slater has done good service by reading a paper before this Society on "Life as compared with the Physical Forces," because it paves the way for the investigation and discussion of this great problem, animal life; and the mode in which the various phenomena are elicited by the animal body, from the motion of a muscle to the evolution of mental power, is a subject to which I have for many years devoted a very large portion of that leisure time which I could snatch from the active practice of my profession; and this must be my excuse for occupying the attention of this meeting for a short time in reply to Mr. Slater's remarks.

I think that a careful perusal of the paper, justifies the remark that the author has taken what may be called the negative view of this great question. I say "great question," because a little consideration must show that it is a question which involves, directly or indirectly, all the best interests of man both in this world and in the world to come. At the same time, it is a question which is often avoided because of the difficulties which have to be surmounted by anyone who ventures to enter upon it. Mr. Slater has reminded us that we can measure light, heat, electricity and magnetism, but that we cannot measure life; and again, he has told us that whilst we can convert the physical forces into each other, we can effect no such transformations with life. In passing

I may remark, however, that "will-power," one of the strongest manifestations of life, is directly capable of being measured by the contractile power of the muscles. A third point of difference upon which Mr. Slater comments, is that life can only exist between certain limits of temperature; and again, if I am not wrong in my interpretation of his remarks, he suggests that because it cannot exist outside those limits, it is not of the nature of a physical force. Another distinction upon which great stress is laid is that whilst we can "start heat, light or motion afresh where nothing of the kind has previously existed," we cannot start life, for "there is no life without a pre-existing life, be it in the form of egg, seed, or spore." I think that there is no one present who would for a moment dispute these statements, but I cannot altogether admit the author's deductions. In as few words as possible I will endeavour to define the views I hold with regard to animal life, and the very important relations which exist between the material body and the physical forces, and between these and the phenomena of life. Of course in these comments I can do so only in the most cursory manner. If we go to the Bible, as we may well do for information on this point, we find it stated that (1) "the life of the flesh is in the blood." (2) "The life of all flesh is the blood thereof," plain statements which demand the most careful attention in any enquiry as to the nature of animal life, and which should be capable to some extent of proof. I had confidence in the assertion, and the results of my investigations assure me that they are literally true.

Many years since I began to study the nature of the blood with the object of ascertaining the mode in which it could be utilised in the maintenance of the energy of the phenomena of life. Physiology had already determined that its power in this direction resided in the oxygen which it contained; ergo, if life is a subtle and non-physical form of energy, it must exist in the oxygen, or the latter could not maintain it in the animal; and, as such a proposition was impossible, the only other reasonable conclusion was that the oxygen aroused vital energy through its physical properties. I next found that oxygen is a highly magnetic substance, and, when it is conveyed into the blood in any quantity, has the power of proportionately increasing the blood's magnetic charge. I therefore concluded, upon this and other grounds, that "life" is essentially a physical form of energy, *i.e.*, that life is

a peculiar description of motion, the character of the motion being regulated by the nature of the forms of matter which compose the organism. To prevent any misconception of the nature of my theory I will endeavour to explain it as briefly as possible. My chief points are as follows:—(1) I recognise, as the only logical conclusion, that all formed matter was created by a power external to itself, and consequently that it had its origin in the Deity. (2) That the same power which created the matter is still upholding it in all its forms. (3) That every form of matter evolves phenomena which are characteristic of that form, and the conditions to which it is subjected. (4) That the material body of a living animal is no exception to these laws, but that all the phenomena of life which it manifests are the immediate result of the work done by the different forms of matter. I hope I have now sufficiently expressed my theory to make it evident that I regard matter as the agent, and the agent only, by which impressed force is directed; whilst the various forms of physical force (of which vital phenomena are one) are regarded as the direct result of the impressions which the different forms of matter, under various conditions, convey to the ethereal medium which pervades all matter and space. Indeed the theory appears to prove that these physical impressions of animal life are registered in ethereal matter, forming the basis of memory, and also of the inward and imperishable man. Of course this theory obliges us to admit the truly mechanical nature of all the phenomena of life, and I know that there are some persons who regard this as a very low estimate of what is the greatest manifestation of the Creator's power. In my humble judgment, however, it greatly enlarges our conception of His power, just as our ideas of the ability of a mechanic are increased by the skill which he has displayed in his work. Again, if this theory be closely examined it will be found that all disorder and disease may be traced to the effect of some impression conveyed to the sensorium, either through the senses, which are truly mechanical, or by the introduction of unsuitable matter into the system.

I will only add my conviction that the Victoria Institute would confer an enormous benefit upon suffering humanity if it would take measures to probe to the uttermost the connection which exists between life and the physical forces, and in such case Mr. Slater's paper would meet with its full reward.

THE FOLLOWING COMMUNICATIONS WERE RECEIVED.

(1) Professor LIONEL S. BEALE, M.D., F.R.S., writes :—

February 18th, 1893.

While I agree with the general views of the author of the paper, I think the facts compel us to go much farther and draw an absolute line of demarcation between all living and all non-living. So far, no properties discovered in any non-living matter justify the opinion of the origin from it of the living. And there is good reason for concluding that every form of non-living matter might have existed for infinite ages and under any conceivable physical conditions, without the most minute speck of the simplest living being evolved.

That which universally distinguishes every form of living matter from matter in every other state is a *property*, *power*, or *agency* by which the elements of matter are arranged, directed and prepared to combine, according to a prearranged plan and for a definite purpose. This power cannot be compared with any known powers or properties. Under its influence the rearrangement of the elements of matter is effected. The matter so acted upon is always colourless and exhibits no structure when examined by the highest magnifying powers; and the changes in question only occur while the matter lives. The power may therefore fairly be called *vital power* and the living matter *Bioplasm*. Now of the chemical composition of this Bioplasm and of its constituent substances we know nothing, and it is doubtful whether we shall be able to ascertain anything concerning its exact nature, seeing that we cannot chemically examine Bioplasm without destroying it. It ceases to be alive and the substances obtained are merely the products which *result after its death*. "Protoplasm" has been applied to matter in many different states and the word has never been defined. Matter alive and dead, structureless and exhibiting structure, matter hard and soft, coloured and colourless, opaque and transparent, cooked and uncooked, has been called Protoplasm. Living matter cannot therefore be properly indicated by a word which is also applied to dead matter.

There is no gradual transition from *non-living* to *living*, but the

two states are absolutely distinct. The living world is not an outcome—has not been evolved from the non-living world. The relation between life, power, and matter is not quantitative, for a particle of matter so small that it could not be seen by the highest magnifying powers at our disposal may be the carrier of vital power capable of impressing with peculiar properties and conferring peculiar structure upon hundredweights of matter which by degrees may come within the sphere of its influence; while, as regards time, this influence may be handed down through ages. I claim therefore for all *Life* a special position independent of, and not in any way related to, any physical forces. Life power must be placed in a category by itself, having nothing in common with any material forces, powers or properties, and holding in the cosmos a remarkable and peculiar place. If governed, it must be governed by laws having nothing in common with those which govern non-living.

(2) From the Rev. R. COLLINS, M.A.

We often perhaps get into difficulties by not distinguishing between abstract and objective ideas. "Energy" and "force" are distinctly abstract ideas, having no existence outside the mind of the reasoner. "Life" is equally an abstract idea.

The lecturer says, "We can measure any of the physical forces by their manifestations; but we cannot measure life by its manifestations." What do we mean, when we say we can measure light and heat? What do we mean by "more or less light"? and "more or less heat"? "More or less light" means, that there are more or less ethereal pulsations on a given point in a given time. We should say the same of what is called "radiant heat." Heat and light are not intrinsically capable of being either more or less subjective (not objective) realities. The same is true of life, regarded merely as to its nature ideally; and that is what appears to be intended by the author. What do we mean by "more or less" life? We cannot really measure either light or heat; we can only measure their energies, which we can only do by measuring the work done by them. Now in the same sense, surely, we can measure life. We can in fact only discern the presence of what we call life—which some call "vital energy"—by work done. And we can measure the work that is done by

the will and energy of man, as truly as we can measure the work done by the energies of light and heat.

The mere exhibition of life for a longer or shorter time in an organic structure does not appear to indicate anything in the quality of life itself, but only something in the quality of the organic structure independent of the life-energy which has been manifested in connection with it.

What are called "physical forces" or "energies," are probably results of ethereal action. Why should not the energies, the working of which we call "life." be so also? May not life be the energy of something, different from that which is at the basis of the "physical forces," but yet something analogous?

So far as we can see, there is probably a more real analogy, than is often thought, between the generation of light, when it has "not previously existed," and the generation of life. If we strike a match in a "cavern" or elsewhere, we are not originating light; we arouse, mechanically, what are called "potential energies" (due to some qualities ethereal or material, which we cannot understand) in the phosphorus of the match and the oxygen of the air, the coalescence of the atoms of which, in some way, stirs the ether around into light-waves. We take potential light with us into the cavern, and we find potential light there. There must be two potentials which coalescing shall result in light. So in regard to life, we must go beyond the *ovum* to the *ovum vivum*: and that we never find, unless two potentials have already coalesced. If we say we can start, or originate, light, we can equally say, that we can start, or originate life, where the two requisite elements can be brought together. If we say, that the life-energy can only be generated by previous life, we can also say, that light can only be generated when two things that have the proper potentialities for light can be brought together. As for "spontaneous generation," whether of light or life, there can be no such thing, as is evidenced in the "physical forces" alone.

When we push back our thoughts to try to grasp the origin of these mysterious energies—all probably results of ethereal action of some kind—we are lost. All we can see at present is, that the mind and will of man are certainly capable of initiating energy; and when we think of the energies of the universe, we can but come to the conviction of an all-comprehensive and originating intelligence, of infinite wisdom and capacity, the Creator.

(3) Surgeon-Colonel S. SMITH, R.E, writes* :—

In commenting upon the subject matter of this important paper, let me premise my remarks by declaring that I am, at the very outset, at variance with the author of this paper in his view of the special nature of vital force; and in his attempt to show that it differs from force in the accepted sense of the term; and I shall venture to state my belief that vital force, or force so called in connection with organic matter, is neither more nor less than force *per se*.

If I ask myself what force or energy really is: and inquire into its origin, I am inevitably brought to the ultimate conclusion that force is in itself the expression of the will of the Creator, existing in all His works, inorganic and organic alike, and manifesting itself in an endless variety of ways.

Let us now consider the nature of vital force, and endeavour to discover the difference, if any exists, between it and force *per se*: or, as we may call it, primary force: and in order to do this we must compare the manifest effects of active vital force with those of force in action.

Force, within and without the body, exists under two conditions (*a*) a latent, (*b*) an active force.

In the organic world it lies latent in the seed as germ life.

In the inorganic world it lies latent as explosives, coiled springs, elastic substance, etc., etc.

Under altered conditions, by the energy of other accessory forces, *e.g.*, heat, moisture, endomosis, etc., the latent life force of the seed becomes active, its manifest effects being those of assimilation and growth; slow in some forms of vegetable life; wonderfully rapid in others, as in the fungi.

In the inorganic world under similar conditions as to accessory forces, the latent force becomes active: the resultant activity being more rapidly manifest as to its effects, the dynamite explodes, the released spring instantly uncoils, the elastic substance suddenly resumes its original length and form.

Here, owing to different conditions, the analogy ceases to hold absolutely good; for in the seed there is a constant accession of force by pabulum, strengthening and increasing the vital force,

* This able communication has been somewhat abbreviated owing to its great length; but it might have formed in itself a separate paper for a meeting of the Institute.—ED.

and enabling it to overcome for a certain time all the opposing forces which, in the very order of things, must at last neutralise it.

In the case of the explosive, coiled spring, and elastic substance the force is constant, as opposed to the incremental vital force of the seed; but in both examples the ultimate result is the same, neutralisation of primary force by opposing force, or forces, producing stasis in the inorganic, and stasis or death so called in the organic world.

In the higher forms of development of the organic world, in respect of which the human body may be taken as the most perfect example, force is active *ab initio*: evidencing its activity by the movements of the spermatozoa producing activity involving change in the Graafian vesicle; and later on evolving the spinal cord and brain, the formation of the heart, and establishment of its continued action in connection with the circulation of the blood; and later still, evidencing its existence by the various functions of the body, many of which are of a purely mechanical nature, *e.g.*, mastication, deglutition, defæcation, micturition, respiration, and muscular movements of the tongue, eyes, limbs, neck, and trunk.

These forces find their analogues, and are identical with, force observed in connection with various machines, of which the locomotive affords an example.

In man this life force, conferred originally upon him by the Creator, has been given in greater or less quantity to each of his children; thus we have from birth weak infants and strong infants. So again vital force is incremental, and can therefore never be constant.

As in the case of infants, so also in respect of engines; we have toy engines capable of exhibiting a small degree of force, and greater engines of higher power.

In respect of this incremental condition of life force, it might be said that analogy again fails to represent the identity of force in the human body and locomotive. Is this so? Give no food to the infant, the life force fails; opposing forces neutralise it, and stasis (death) follows. Cease to supply the locomotive with fire and water, and you open the valves in vain, stasis follows from neutralisation of opposing forces. God gives primary force to the child, man supplies it to the locomotive.

So that if life force fails for want of pabulum (food force),

does it not follow that the force which is supplied by the food is identical primarily with that of life force, else why the result?

As to the functions of the organs of the senses, are they not evolved by force from without? *e.g.*, of the eye from the impact of light, and the effect of its transmission through the organ to the brain.

Of the ear, from the impact upon its drum of vibrations conveyed by the atmosphere and their transmission to the brain through membrane, ossicles, etc., and so on with the other organs.

With the special recognition of these forces as seeing, hearing, smelling, touch, and taste, through the medium of the brain by the inner or spiritual man we have not to deal. Our theme is the identity of force; our field the conflict of force.

We do not say for a moment that primary force, or at least a portion of it, is not convertible; or, to put it more clearly, capable of acting in more than one direction: or that it may not be modified, and apparently but not really changed as such, by the conditions under which it is placed.

Let us now glance briefly at force in connection with the brain and spinal cord; and compare it with that observed in connection with a battery and accumulator.

In both cases force originates from pre-existing force active in the brain and spinal cord, latent in the battery by the agency of the pre-existing active force; the brain and spinal cord at the will of the Creator were formed. By man, the battery was constructed, and its force lies latent. So also does life force lie latent in the seed. Force in connection with the brain and spinal cord exists *ab initio*, and is increased and maintained by decomposition of organic matter within the body, the latent force of which organic matter it assimilates.

The brain and spinal cord is a living battery and accumulator, whose nerve trunks are conductors.

Force in connection with a battery becomes evident when it is rendered active by decomposition of inorganic matter, and interchange of elements liberating latent force.

In both cases, after a certain time, stasis results in respect of the brain and spinal cord, from want of food force, or it may be shock or injury; and in that of the battery, from want of undecomposed inorganic matter.

Heat, as an evidence of force, is evolved by a battery in action.

So also in respect of the spinal cord and brain the same result follows, *e.g.*, in blushing and flushing reflex conditions arising out of some temporary alteration of the normal quantity of vital force conveyed by the vasomotor nerves.

Light is produced as a display of electrical force, under the usual conditions of interrupted current, etc. So also is light, or that condition of force which gives rise to it, produced when force is suddenly and abruptly applied to the organ of vision, *e.g.*, by a blow; or, when the eyes are closed, by pressing the fingers upon the eyelids so as to cause pressure upon the eyeballs, assuming, with regard to the blow, the appearance of a flash of light, or a myriad of bright sparks; and from pressure by the finger that of a ring of light; such efforts, as in the case of the battery being obviously due to interruption of a current of force.

Shock results also from interruption of an electrical force current.

So also as to the brain and spinal cord similar consequences follow, *e.g.*, a blow over the ulnar nerve gives rise to shock from sudden stoppage of vital force current.

Small shocks producing pin and needle sensations are experienced by the use of the battery and coil, etc. The same sensations are the sequence of partial pressure upon a nerve trunk.

Complete hindrance to electrical force current and vital force flow entail the same results: cessation of all manifest effects of the former; and abolition of functions of parts supplied by the latter.

In connection with a battery, we see under certain conditions—mechanical effects of electrical force—or so-called conversion of the former into the latter, these effects being, however, neither more nor less than qualities of primary force rendered evident by the conditions under which it is placed. In like manner we find the mechanical effects of vital force in connection with the brain and spinal cord rendered evident by the conditions with which it is associated, and under which it is placed; giving rise to mechanical motion in the body wherever needed, *e.g.*, sucking, mastication, deglutition, evacuation, heart and artery movements, respiratory, limb and general movements of the body through the agency of the muscular system.

The ball and socket joint of the scapula and humerus with its associated muscles affords an example of adaptation and construction, such as permits of a display of every form of

mechanical motion, which the most complex machines are capable of performing.

Is it not clear then that vital force associated with the brain and spinal cord effects all these mechanical movements of the body, just as the electric or steam force acts upon the movable parts of the machinery upon which they are brought to bear? In each case a movable body, or parts of a body—applied force—and movement as a result.

Does it not further appear that a current of primary force holds within itself as properties or constituents of it—as in the case of a ray of white light—in a state of parallelism—heat, light, electricity, actinic, and probably other forces—as yet unknown to us, which do become manifest when its parallelism is disturbed or destroyed.

We have now to consider an important statement by the author of this paper, viz., that vital force, unlike physical force, cannot be measured; and he asks for a measure of life force, and standard of comparison.

Now, if we seek for this measure of life force and standard of comparison, we must search for it among the opposing forces of life, of which it may be truly said "their name is legion," *e.g.*, starvation, blood-letting, poisons, etc., etc. From all these we may, with most advantage, select that of poison, the power of which, in opposition to that of life force, is now so well-known, as to enable us by its means most readily, and with nearly absolute certainty, to estimate the quantity of life force present in some organic bodies.

As to the degree of vital force existent in different individuals, in animals, and other organic forms of life, it is clearly and undoubtedly evident that to no two bodies has the Creator accorded exactly the same measure of vital force. Daily the old aphorism of the famous Greek physician presents itself to our minds in all its completeness and truth, "We differ from ourselves at some times in our lives, no less than we differ from everybody else at all others." If this be so, as exemplified in each individual, in infancy, youth, and old age—owing to antecedent or hereditary causes producing difference of quality of structures—inherited and acquired; from opposing forces of disease—inherited and otherwise; from mode of life, *et alia inter alias*, it follows that no absolute standard of vital or life force *per se*

exists; but we can measure it relatively by those forces to which we have already alluded.

For, notwithstanding the difficulties which beset and attend such an investigation, we start with the knowledge that a given quantity of poison force contained in its alkaloid will—if administered or injected into the body—neutralise, *i.e.*, bring about, stasis of its vital force; or in other words, cause the death of such an organic body; and further, that the force employed to produce such a result must equal the vital force existent in that body or stasis would not follow. So that we may say in respect of this, that as nine-tenths of a drop of anhydrous prussic acid will cause the death of an average man, it necessarily follows that the vital force of the man must be represented by the value of the neutralising force of the nine-tenths' drop of the prussic acid.

This comparison of opposing force with life force may be extended so as to include the reptilian, insectivorous, and other poisons.

Possibly a more correct standard of the value of vital force will be found in electricity; to which, under certain conditions, as a means of extinguishing life in the criminal, the attention of the civilised world has been of late directed; and the intensity and quantity of electricity necessary to accomplish this, has been sought for, so as to ascertain the exact measure of electricity necessary to neutralise it.

By a less certain method of average as to duration of life force in individuals, does the actuary attempt to find its value.

With reference to the question of effectual resistance of vital force to opposing forces such as we have dealt with, which are cited by the author, and of which we are cognisant, their very existence only proves the truth of the old adage that "there is no rule without an exception."

To attempt to show in the present state of our knowledge the why and wherefore of these exceptions would be futile.

Why, for instance, parsley kills parrots—goats can browse upon hemlock, enjoy it and suffer not.

Why—as cited—the tsetse fly kills some animals and is harmless in respect of others.

Why eggs and mutton produce symptoms in some persons analogous to poison, etc., etc.

In regard to all these and similar exceptions, we can only assume that as life exists in a greater measure in some bodies than in others, the resistance is correspondingly greater; and that where this is not the case, that some difference of structure exists; or that some glandular product is formed; or that some principle exists, possibly, and most probably in the blood itself, constituting a force which neutralises that opposed to life force, and thus leaves it untouched.

These comments touch not upon the power of the will in connection with force associated with organic matter; but seek to show that force so associated, however divergent, however apparently changed, however different in effect, is still primary force *per se;* the expression and manifestation of the will of the Creator, arising at His command, continuing during His pleasure, pervading all His works, evidencing its existence alike in the lowest and highest forms of life.

(4) From the Rev. H. J. CLARKE, M.A.:—

In endeavouring to show that life has no place among the so-called physical forces, Mr. Slater directs attention at the outset to what appears to me to be a conclusive argument. In light, heat, electricity, chemical change, and mechanical action, a convertible energy, measurable by its manifestations, and capable of representation by definite quantitative values, circulates among these classes of phenomena, discovering itself now in one, now in another. Life then, if it were some development of this, should admit of being measured by its manifestations. But such is not the case, and the difference between the two in this respect is not doubtful, but patent and striking; therefore we are entitled to regard life as an essentially distinct agency. But what conception are we to form of the *modus operandi* in the manifestations of the physical energy? Mr. Slater reminds us that there are persons who hold them to be manifestations of "certain modes of motion." I presume, however, his opinion is that he might grant this assumption without thereby conceding that they are thus accounted for. On the other hand, he would perhaps allow, at any rate his argument does not compel him to deny, that all the changes which constitute the phenomena of purely physical life, admit of being conceived as modes of motion. For its starting

point in every case may be scientifically represented as a specific arrangement of molecules, in association with a tendency to select from its environment, under favourable conditions, suitable materials, to attach them to itself, to fashion, in conformity with a type to which it owes its origin, the structure which thus arises, to preserve it, in the process of waste and renewal, for as long a time as possible from the disintegrating operation of hostile tendencies, to adjust within certain limits its internal economy to alterations in its environment, thus maintaining, while it lasts, a moving equilibrium. Accordingly, if physical life, whether vegetable or animal, presupposes movements among molecules and atoms, and is scientifically distinguishable from its absence by the characteristics which are to be ascribed to such movements as are specifically its own, we are at liberty to affirm, not indeed that we have hit upon a phrase which accounts for life, but rather, that within the range of physical investigation we have arrived at no deeper discovery respecting it than that its phenomena imply modes of motion peculiar to itself, and, in the stamp they have received from the Intellect which designed them, sharply distinguishable from all other modifications which take place within the frame of nature in the way of molecular arrangement.

The proved impossibility of converting into life any inferior manifestation of energy, and the now established truth that every germ presupposes a parent life, are doubtless very instructive, if thought be directed to some far distant past when physical life could nowhere have been possible in any of the forms that are known to us. But in seeking to discover when it began to be, what do we aim at, if we ignore the question, whence comes the energy which has produced the universe, and has been ceaselessly at work throughout it from the beginning? Do we desire to trace cosmic energy to its source? Then must we not assume the all-pervading operation of an originating Intellect and Will.

(5) From Mr. D. BIDDLE:—

This interesting paper brings forcibly to one's mind Professor Allman's presidential address to the British Association, in 1879, on *Protoplasm*. He very truly said, "wherever there is life, from its lowest to its highest manifestations, there is protoplasm; wherever there is protoplasm there too is life. The chemical

composition of protoplasm is very complex, and has not been exactly determined (but an advance has been made in this respect, during the thirteen years which have elapsed, as Mr. Slater clearly shows). It may, however, be stated that protoplasm is essentially a combination of albuminoid bodies, and that its principal elements are, therefore, oxygen, carbon, hydrogen, and nitrogen. In its typical state it presents the condition of a semi-fluid-atenacious, glairy liquid, with a consistence somewhat like that of the white of an unboiled egg. While we watch it beneath the microscope, movements are set up in it; waves traverse its surface, or it may be seen to flow away in streams, and this not only where gravity would carry them, but in a direction diametrically opposed to gravitation; now we see it spreading itself out on all sides into a thin liquid stratum; and again drawing itself together within the narrow limits which had at first confined it, and all this without any obvious impulse from without, which would send the ripples over its surface, or set the stream flowing from its margin. No one who contemplates this spontaneously moving matter can deny that it is alive. Liquid as it is, it is a living liquid; organless and structureless as it is, it manifests the essential phenomena of life." Such was the president's lucid description of protoplasm. But, as I remarked shortly after his address was delivered, there is not one phenomenon mentioned which has not its counterpart in the merely physical world. Protoplasm is simply peculiar in combining the whole. 1. The chief elements of protoplasm, enumerated by the professor, are equally contained in the sesqui-carbonate of ammonia. 2. Its consistence may be stimulated by various inorganic solutions, not to mention collodion. 3. And as to the movements of protoplasm, in what do these differ from those of the sea upon the shore, except in the matter of rhythm? There we have apparent expansion and contraction, and an upheaval of the substance, which only science has taught us to be due to something outside itself. And if this be beside the mark, what are we to say to the evaporation of water by the stimulus of heat, and the condensation of vapour by cold? What are we to say to the diffusion of gases and of liquids, and to their endosmosis and exosmosis through dead membranes? What, moreover, are we to say to the process of solution, by which a small portion of the chemical compound mentioned above, placed at the bottom of a tube a foot in length, can, by the simple addition of water, be

raised "in a direction diametrically opposed to gravity," so as to occupy all parts of the vessel? Is not vital action after all quite distinct from, and much above, the phenomena enumerated by Professor Allman as belonging to protoplasm, and are not these after all only the physical phenomena of what Professor Huxley justly calls "the physical basis of life"?

(6) The late Dr. JOHN RAE, F.R.S., in a letter to the Secretary, not intended for publication in full, says:—

February 20th, 1893.

"There are certain things that are placed beyond the keenest and most educated human intelligence to understand and gain an insight into, yet I believe that new creations are taking place every day."

(7) From Professor BERNARD, Dublin University.

February 17th, 1893.

MY DEAR SIR,—Mr. Slater's comparison of the vital forces with the forces of heat, light, electricity, etc., is very interesting. The facts that life is not susceptible of mathematical measurement or of conversion into other forms of energy, as far as we know, are significant. But the kernel of Mr. Slater's paper is, I take it, the third point insisted on by him, viz., that *Biogenesis*—life from what has life already—seems to be the law of nature; and that for *abiogenesis*, or the production of living organisms from inanimate matter, we have not a particle of evidence. The only reason that has been alleged for supposing it to have taken place at some remote epoch in the past, seems to be that otherwise we come upon a breach of the Law of Continuity, which is our guide in the scientific investigation of nature. But why we should suppose the law of continuity to be thus absolutely binding is not easy to see. The formulæ for the conduction of heat, *e.g.*, distinctly show *discontinuity*, and in other branches of science there are not wanting indications of past crises in the history of the earth and the life upon it utterly unlike anything that has happened since. And therefore it does not seem unscientific to postulate a crisis of this kind at the epoch when life was originated. All the evidence, as Mr. Slater and other experts tell

us, points to the vital forces being *unique*, not comparable to or interchangeable with other forces of energy. But while this is true, I should not care to build any theological superstructure upon such a basis. An argument from ignorance is at any moment liable to be overturned by the discovery of fresh facts. The origin of thought, rather than the origin of life, is the point at which we come upon an impassable barrier, not merely a barrier that has never yet been crossed.