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ORDINARY MEETING.*

D. HOWARD, ESQ., D.L., F.C.S., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed.

VITALITY. Lecture by Professor LIONEL S. BEALE, F.R.C.P., F.R.S. Second Part. For Part I, see Vol. XXXII, page 337.

MR. CHAIRMAN, LADIES AND GENTLEMEN:—This subject of vitality is just now of the very greatest interest, not only to the scientific, but to everyone. The question of vitality is a very old problem. Many and very different views concerning it have been entertained, and it seems to me to be time that those conclusions, which are justified by science concerning the problem of vitality, should now be considered from the point of view of modern minute inquiry and microscopical investigation. This has not yet been carried out. The broad general question of the nature of life certainly has been discussed by the wisest for ages, but the bearing of the facts ascertained by recent investigation—the structure and the manner of growth of living things—have not been adequately considered and debated of late years by the light of our new knowledge.

Vitality has an important bearing, not only upon fundamental questions of minute anatomy, physiology, biology, botany, zoology, medicine, and surgery, but views concerning the real nature of life have always had considerable influence upon the religion and philosophy prevalent at the time. All scientific men who regard with interest our whole living world, in which man occupies the most important place, hope, sooner or later, to learn something more definite than has yet

* Monday, March 6th, 1899.

been discovered concerning the general nature, and if possible the origin, of life. The differences of opinion now entertained are extreme and irreconcilable. Some authorities maintain that living things are entirely dependent upon *physical and chemical changes only*, and that varying conditions acting from without also exert a powerful influence. Indeed, by many this external influence is supposed to be all sufficient to account for the vital phenomena occurring within every living organism. Some look upon living things, including ourselves, as mere machines—*as machines such as are made by man.* On the other hand, in favour of the view that all actions occurring in living organisms depend upon vital power, and that there is nothing mechanical in *life, growth*, and *vital action*, the evidence is strong.

Again, some hold that there is no evidence of design—no plan or purpose in creation. Twelve months ago Dr. Walter Kidd gave us a most interesting paper on this great question, and it is to be regretted that he has not been rewarded for his trouble by adequate intelligent discussion and criticism. Many papers read here certainly deserve more notice, more consideration and discussion than they meet with; and scientific men who differ ought certainly to state the grounds of their opinions, instead of repeating conflicting doctrines again and again without replying to the objections which have already been raised to their strange physical views. Having asserted their physical doctrines, they leave the problem of life as it was, severely alone, in the hope, I suppose, that no more will be said. But in the interests of scientific truth this cannot be right. For in science, if a contention concerning a broad principle long held, and strongly insisted upon by authority, and taught in schools, remains unproved for years, and is not defended by those who maintain it, it should certainly be subjected to full discussion. It has been asserted again and again that by chemistry, physics, and mechanics vital changes are to be explained, but no one has yet succeeded in explaining them.

There is in every vital action what has been learnedly called the operation of a "factor," which factor unquestionably has nothing to do with physics and chemistry. There exists in all living a *power* of making definite arrangements, a governing, a guiding power—a power which compels component material particles (atoms?) to take certain definite positions with respect to one another, but which operates only in living matter—a power which somehow exercises in

life a control over the materials, which control is lost *the moment the matter ceases to live.* This must be admitted. What power this something actually is, what it ought to be called, is another matter. Most of the German authorities now seem to prefer to called it "energy"; but then they use the word "energy" as some distinguished scientific philosophers use some other words—in more than one sense. It is this varied use of words and vague definition which is really one of the greatest difficulties in discussing some of the most elementary scientific questions. One of our greatest philosophers has exposed himself to this accusation—I mean Herbert Spencer. Were one driven to do so, one could pick out not a few passages in which a word is used in one particular way, and a little farther on the same word is used in a totally different sense. Especially is this the case with respect to the words "*organic*" and "*growth.*" The first will include *living* and *dead matter*, and the second is made to include *lifeless aggregation* as well as *living growth.* Here I think no compromise is possible. The two opposite views as to vitality—one attributing it to mechanical agency and chemical and physical changes—the other referring all vital phenomena to some force or power which cannot be isolated, estimated, measured, or weighed, and which is so to say not material, not a necessary property of any form of non-living matter. This power is a factor which acts on matter, but it does not come from matter. It is an agency *which ceases to act when living matter dies.* These two views, *the physical and the vital view*, are irreconcilable. They cannot both be true. One must yield. Whether it shall yield now, or ten years or a hundred years hence, it is not possible to say; but one of these two views must be wrong—not only erroneous, but absolutely untenable. I have no objection whatever to admit that I am wrong; for I am old and ready to admit my mistakes as soon as they are made clear, but let them be proved and then exposed. Those who differ from me, as many do differ and have differed for more than forty years, should clearly express their points of difference as regards broad principles, and reply to the many "appeals" I have made. (Applause.)

In the *Spectator* of this week there is an interesting paper on what the author calls "The Uses of Agnosticism." It is a very curious communication, and I would recommend all interested in this discussion to look at it. I must not, of course, enter into a consideration of all that is said, for it

would take much time; but like many of the scientific articles that appear in the *Spectator*, an opinion seems to be almost accepted in one place, and gently condemned and doubted in another, leaving the reader to infer that neither of two opposite views is wholly right or wholly wrong. The *Spectator* does not assert, and no paper has yet said, that the agnostic holds such and such views correctly. Many people call themselves agnostics, but when you talk to them or read what they have written on the subject you find that they evidently consider that they know all that can be known, and lay down the law in a way that is not considerate towards anyone who doubts whether he *knows*—who in truth *is* agnostic concerning many things. But the "*agnostic*" is most knowing. In the time of the ancient Greeks the same sort of thing occurred. Certain people advanced reasons, and advocated *reasoning* in the most patient and considerate way; but some seem to have been devoted to dogma of the most tremendous kind. In modern days I do not say that great scientific authorities are more dogmatic than ancient philosophers; but those who a few years ago were proud of their agnosticism would say, for example: "Man is a machine, and all his actions are mechanical"—a rather confident assertion for an unsophisticated, simple, not knowing, modest agnostic. No man, animal, or plant is a machine or is formed as every machine from the very first in existence was made—in pieces; and no human, no vital action is purely mechanical or chemical. Again, with regard to the word "evolution," which is in everybody's mouth, and is applied to politics, philosophy, religion, music, poetry, history, thought, and learning as well as to windmills, water-mills, instruments of all kinds, and articles of dress!

Evolution unquestionably occurs in all life; *but the seat of this evolution is the inconspicuous, colourless, structureless living matter.* Different kinds of living matter may be examined by the highest magnifying powers, and yet we shall obtain no indications of structure. Such is the only material in which true evolution occurs in all life. Living matter comes from living matter which existed before it, and the last from previously existing living matter, and so on, as far back as we may proceed. As to *structure, when evolution is proceeding, there is none.*

Structure is not produced from the structureless, for some time. This seems to me to be the truth with regard to

evolution, and those who talk of animals being evolved from more simple or lower creatures existing before them do not make their meaning clear, and they say that such vast time is required for the performance of the changes assumed that we are lost in a sort of vague cloud-land, where anything or everything *may be*, but nothing capable of demonstration *is*.

Like many wild notions of our time, not a few of our philosophical ideas are so vaguely and yet so cleverly stated that it is impossible to contradict them; but, as it seems to me, the word evolution, as generally used, refers to modifications affecting the whole creature *as it is*. While in truth the changes assumed are prepared for, and can only occur in the living matter at a very early period of development when the minute germ is structureless, and the semi-fluid matter of which it consists is so delicate that without the greatest care its arrangement and relations cannot be studied with success, it is to such minute particles of living matter that any process of evolution must be restricted.

Next, with regard to the use of the words *living* and *dead*. Many seem to think that living things gradually die; gradually pass from the living to the dead state. This is not the fact. The passage from the living to the dead condition of a given living particle occurs suddenly, and the difference between the two states of the matter is absolute. There is no gradation, no slow transition from life to death, in the case of any form of living matter, and nothing that does not live can die. There is no transition that can be made out. A particle of living matter is either *living*, or *it has ceased to live*—either *living* or *dead*; and as far as I know all instances of dormant vitality that have been brought forward and called dormant because they are not active are really alive. There is no instance in which life can cease for a moment without *death* occurring. The difference, I repeat, is in all cases *absolute*. The particle of matter that dies *never lives again*, and this seems to me a point which ought to have been considered long ago, but it has been evaded. There is only one way in which non-living matter can pass into the living state, and that is by the agency of a living particle of some kind. There is no instance known of any non-living matter of any kind becoming *living, except by the direct and immediate influence of living matter which existed before it* upon the non-living matter that it takes up or that is brought to it. The living matter always takes up the non-living matter and communicates its *vital* power to this

matter, which then becomes living, and this, as far as we know, is the only way in which living matter has ever been produced. There is no gap, no jumping of the non-living particle into the living state. There must be absolute contact, an absolute mingling or blending, and as it were an interpenetration of the non-living into the living. The power or property of the living is communicated to the new matter, which up to that moment was but the food introduced from without. In attempts to explain there has been much confusion, as I have said before, in the use of words. "Organic," for instance, has been used where living or "vital" is meant. "Organic" is applied to much matter which is not alive; that which is organic need not have been made by living things at all. There are hundreds of substances which are "organic" and can now be made in the laboratory, but no chemist has yet turned out a living particle, though some enthusiasts who are not chemists have confidently declared that the thing will be done. Everyone who patiently studies living matter itself, and the important part which this structureless living matter plays in the formation of tissue, knows that this artificial manufacture is and will ever remain impossible.

No one who has studied the subject would dream of the chemical production of life, or of the *spontaneous origin of life*, even as a very remote possibility. Thousands of things that are organic are kept in bottles and are not, of course, alive, or capable of living. Therefore, the word "organic" ought to be restricted to its proper meaning. So with regard to the words "increase" and "growth." Increase applies equally to living and non-living. Growth is applicable to living matter and things only. There is no true *growth* in anything except through the agency of living matter. When we talk of the *growth* of a stone or a crystal, we mean only that they increase in size; but they do not *grow*. In the same way a number of instances will occur to every one, in which there is increase in dimensions but no *growth*, as I have for forty years contended, and so far only one or two have expressed any objection to my conclusions. Of these, one opponent in my own profession committed himself to the opinion that, like trees, volcanoes *grow*. The same has been said of glaciers and many other things. But really it ought to be unnecessary to enter upon a discussion of so obvious a fact.

Again, there are the words and the processes of "*integration*"

and "*disintegration*," and a number of others that I might mention as applicable to non-living matter, which are also applied to things alive. It is of course necessary to insist that in any discussion the exact meaning attached to the words used should alone be adopted. We must remember that the Greeks taught us the necessity of moderation, of limitation, of restraint in reasoning and philosophical discussion.

Now, the conclusions which I venture to bring forward with regard to vitality are conclusions which rest on facts of actual observation on the nature of things I have myself seen and examined many times.

It may seem strange for an advocate of minute investigation and microscopical research towards the close of the nineteenth century and familiar with the best instruments and the highest magnifying powers, who therefore must be greatly interested in modern work, to extol Greek methods and Greek thought. I cannot, however, help alluding to a word which has been particularly advocated and explained by Mr. Benn, who is the distinguished author of an excellent book published within the last three or four months, called *The Philosophy of Greece*. Now in this book Mr. Benn tells us much about Sophrosyne, which according to him should be understood to mean "*self-knowledge*," *self-control*, the ruling principle of Greek life, Greek art, and Greek thought.

We, as followers, ought to be moderate in our views, at least until we are perfectly certain we are right. Even in science we ought not to be too certain, or to claim authority except it rest upon evidence. Few things do more harm by retarding real progress, and by interfering with the progress of knowledge, than the fashion of raising up "authorities" one after the other in science. There is no authority in science. The question is not as to authority, but as to fact. It is by the finding out and the demonstration of new facts that science is advanced. And scientific discoveries are more difficult, and far more laborious, than making the generalizations which indeed usually follow almost as a matter of course.

There ought indeed to be exercise of self-restraint, and, as Mr. Benn says, "Socrates applied to words and to their correlative mental representations the old Greek method of limit and circumscription, imposing the duty of Sophrosyne on thought itself" (p. 174, *The Philosophy of Greece*, by Alfred William Benn, London, Grant Richards). I will just give one more extract from this very interesting and

highly instructive book:—"People cannot carry on a discussion profitably, or even decorously, unless they are agreed about the meaning of terms. If you and I are to play dialectic together, the pieces—in this instance words—must have the same value for us both, and we must stick to the rules of the game, otherwise, as Aristotle says, 'there will be a disgraceful scene.'" (*The Philosophy of Greece*, p. 174.)

I never read an extract that seemed more interesting to the student of science or more pertinent to modern ideas than this, which relates to the philosophic views of more than two thousand years ago. As we all know, there might be "terrible scenes" if the representatives of conflicting philosophies met for discussing the merits of their several doctrines at this time. The difference between thoughtful persons is great and unfortunately a great many words, as I have before remarked, are used in more than one sense. There must be many scientific controversies, many crises, much strife, which might bring about "terrible scenes." Among the most terrible things that have been said of late is perhaps the comparison between the changes that take place in the "growth" of a volcano which does *not grow*, and an oak tree which does *grow*. Mr. Herbert Spencer is in great part responsible for this. I shall have something more to say about this question of growth later on. But is it not very extraordinary that anyone should attempt to compare the changes taking place in a non-living volcano with those, constant during its life, of a living oak tree? Are they not obviously, absolutely different? Between them there is no analogy. It would be very interesting if those who accept such comparisons would put their views into plain English, so that we may discuss them. One word let me say with regard to this matter, though it may be perhaps a little personal as regards the discussion into which I have entered. There has been a slight tendency on the part of some who differ from me to call me names. One controversialist denominated me a "Spiritualist." Now I never was a "Spiritualist." The term "Spiritualist" is not applicable to me, because, as I said before, my views entirely depend upon the demonstration and repetition of facts of observation made in the course of my own investigations with very high magnifying powers, the results of which have been published in several memoirs and scientific papers communicated to the Royal Society, the Royal Microscopical

Society, and to the Victoria Institute, and several works—*Protoplasm, Bioplasm, Vitality*, etc.

Biological investigation has been indirectly greatly advanced by bacteriology. Very high powers, of good definition, magnifying 600 times or more, are required in both departments. We have been able to discern living particles which are less than $\frac{1}{10,000}$th of an inch in diameter, and many important facts relating to "life" have been made out. Bacteria in their millions might lie in a space less than a quarter of an inch square without being crowded. Many of these minute organisms are unpleasant creatures, and some are dangerous, but the great majority of them are perfectly harmless. Millions and millions of harmless bacteria exist outside and inside most living things, multitudes are present in the food we eat. In every cell of vegetables which are kept by the greengrocer for twenty-four hours, or even less, they abound; so that there is nothing to be feared except in regard of certain specific kinds.

I am old enough to recollect the time when because one talked of things being magnified 700 or 800 diameters we were looked upon as very fanciful creatures, speaking familiarly about strange and unheard-of things. But now microscopic powers may be used, and with success, which magnify more than 1,500 diameters. Let us consider what this enlargement means. By "one thousand linear" or "one thousand diameters" we mean that a little particle, whatever may be its nature, is made to appear a thousand times longer or wider than it is, and the use of the word *linear* is important. We measure merely in one direction, either from right to left or from above downwards over the field in one direction only.

A thousand diameters in these days is not very much; but if a thing were enlarged only 300 or 400 diameters you would be surprised how large it would appear. If the body, say, of a frog, could be magnified in this degree 200 or 300 diameters, it would appear to be 60 or 70 feet long. So, a man magnified in the same degree as a particle of one of his tissues might be under the microscope, would appear to be as tall as a high mountain.

The relative proportion of bioplasm or living matter in a tissue is much larger in young than in fully formed animals of the same kind, and in old age the proportion becomes less and less. The proportion of living matter in the growing embryo is considerable, and the very young embryo consists

almost entirely of living matter, which contains perhaps more than 90 per cent. of water. As growth proceeds, in many tissues, the little living particles of bioplasm become gradually separated a little from one another by the material which is slowly formed on the surface of or between each. This matter has been *formed* by the living matter, but it is no longer living. It may be called formed matter. In this diagram the living matter is coloured red, but the formed matter is not coloured. If I take a very thin piece of cartilage of a kitten at birth, and compare it with that of another six weeks old, and with yet another from a young cat, and lastly with one from a mature animal, all having been prepared and stained in precisely the same manner, you will find the proportion of living matter in the cartilage tissue, relatively to the amount of intervening formed material, is *much greater in the young* than in the older and fully developed animals. These changes are continually going on, not only in one, but in all the tissues of the body, and at the same time, as the several textures advance towards their fully developed state—towards maturity.

Now this *colourless material* in each drawing is that which does *not* take up the carmine colouring matter. It is *formed matter, structure, which is no longer living, and is incapable of growth and of forming more matter like itself;* and in cartilage, fibrous tissue, hair, nail, horn, the tissue or formed matter becomes nearly dry. On the other hand, the living matter, in its natural living state, is invariably structureless and colourless, and contains a very large proportion of water—very often as much as, and I think sometimes even more than, 95 per cent. But I do not think a single instance can be brought forward in which living growing matter contained much less than 80 per cent. of water. In a very active state of vitality, no doubt living matter may be associated with a much larger percentage of water for a time. You cannot have living matter without a large quantity of water being associated with the minute amount of solid matter. This living matter or bioplasm is, as I have said, colourless and structureless. All matter that is alive—that exhibits *vital action*, which is concerned in vital movements, changes, and the living matter which takes part in touch, taste, sight, or hearing, and is present in all sense organs, in all forms of animal life—is living, and upon it alone *vital* activity entirely depends.

I do not believe there is an action, a thought, or a vital

movement in which a proportion of bioplasm does not cease to live. In active life, the place of the minute portion which is changed—which "dies"—giving rise perhaps to vital movement and other phenomena, is taken by the conversion of a corresponding portion of non-living matter (nutriment) into the living. These views lead one to try to form a sort of mental picture of life in action—changes absolutely impossible to see and study in the case of a complex organism like man and that of the higher animals, but to be demonstrated without difficulty in the case of some low and comparatively simple living organisms.

No man could in a portion, say, of the active part of the brain, or indeed of any part of the body the size of the head of a very small pin, see, as it were, mentally, at the same moment, all the vital and other changes which are taking place in that one small piece of brain matter—perhaps in the thinnest section, the thousandth part of an inch in extent; but it might be possible, from observation of the arrangement of the structures, to form a conception, though hardly a mental picture, of the wonderful changes going on during one moment of action or rest from action, but this probably is the utmost that can yet be gained by one who has a good knowledge of the facts known concerning the development and growth of the so-called "brain cells" and their phenomena during life.

In some of the lower living organisms, the comparatively simple amœba for example, a correct general idea of what occurs in the bioplasm or living matter of the minute living particles concerned in mental vital action may perhaps be formed. A young amœba possibly contains, in a given minute portion, more matter actually alive at one moment than any other living particle that can be examined separately without causing death or irreparable injury. This living matter seems to be, to the highest magnifying powers obtainable, as structureless as water. By the spontaneous movements effected by vital power, small portions may be detached, and these may further divide and subdivide. Thus from one small living particle a great number may be produced, every one possessing precisely the same powers as the original particle from which they originated.

Let me now offer a few remarks upon some organ which in its active state will help us to form some idea of the wonderful changes which are going on in our bodies during

life. The organ which I think is most suitable is the heart. Consider for a moment how very interesting and important are the changes which take place from moment to moment in the heart, in every part of the muscular substance of the heart, which is continuously at work from before birth to old age and death. The alternate shortening and lengthening of the muscular fibres never stops for many seconds. The heart never *rests*. The nerve cells and the ganglia which govern its action and determine the healthy regularity of its beats never sleep. The sustained action of the heart, and as I venture to think of all muscular tissue, is indirectly dependent on the living matter of the muscular fibres and that of the nerves and ganglia connected with it. But I dare say this view will be contradicted, though probably not in print. I should like those who differ from me to state the ground of their objection. All muscles and all kinds of muscular tissue are everywhere supplied with nerves. There are nerve ganglia in the heart itself, by which the activity, regularity, and equality of the muscular contraction in its several parts is provided for. Remember that the heart is not the only one of our organs which never rests and never goes to sleep during life. Its "nutrition" proceeds without interruption, and the perpetual removal of the products of decay are provided for by a number of complex changes which do not cease during life, and our health and strength and working power are maintained and longevity rendered possible. On the other hand the muscles of the limbs and body generally do require rest, and if worked too hard become tired, and then rest for a time becomes imperative. The heart continues to beat perhaps sixty or more times a minute, perhaps nine or ten million beats in a year. Many of us in this room now have experienced many millions of beats since our heart was first formed, hardly conscious of the necessary and wonderful work incessantly going on in our body. But the wonder is increased if we consider the steps of the formation which proceed early in life, for while its work goes on in the early years, at the same time that the heart continues to *grow*. The heart is one of the first organs that performs actual work in the organism. In the chick the heart and corresponding part of the nervous system are formed very early in the period of incubation. In a few days, and in the eggs of small birds probably within forty-eight hours of the egg being laid, there would be indications of the heart, and not only so, but the red blood is at the

same time formed and is ready to circulate in the vessels also developed very early. Again, the heart, if it is in good order, is the most remarkable organ for undertaking a *varying* amount of work without damage. It may be called upon at any time to perform much more than double its ordinary work in a given time. If you run for a short distance you will find the heart beats twice, or more than twice, as quickly as ordinarily, the number of beats rising to one hundred and twenty or more per minute; and if the heart is healthy, and we rest for four or five minutes, it will generally be found to have returned to its normal rate of action. If at any time you find the increased action goes on for long it is very desirable not to allow the heart to be again unduly excited. There are people whose hearts are so sound and strong that they can do at the age of sixty or seventy almost as much as at twenty; but such organisms are not very common.

The heart requires no attention, no direction, and no thought on our part. Many of us unless we feel our pulse or put our hand where the heart is situated are not conscious that we have a heart steadily working without interruption, day and night, from months before birth to death, at the average rate of sixty or seventy beats per minute. The heart does an enormous amount of work, and when we consider the circulation in the case of large animals—for instance, the elephant or the whale—the amount of work done by the heart is indeed enormous, each forcible contraction driving the blood through the vessels continually—contractions succeeding one another at certain short but definite intervals during the whole life of the creature.

I can only briefly refer incidentally to a few points in connexion with the structure of the heart; but the inquiry is of the greatest interest as regards the principles and nature of nervous and muscular action. A very thin section must be made; or, better, you may appeal to some small animal, parts of whose heart are naturally so thin and transparent that a section is not required. In my favourite little *Hyla viridis*, or Green Tree Frog, which is better known in Germany than in England, I have seen perfectly what I have seldom demonstrated in other animals.

The Hyla is a beautiful little creature with tactile tips to each toe, acting like suckers, so that it can stick to the smoothest surface of leaves or even of glass. It jumps, for

its size, a long distance. It is of a beautiful green colour, changing from light green to dark greenish brown, and may easily escape notice on a leaf. Many of these animals are brought over to England every year, and people keep them as pets and feed them with flies.

The muscular walls of the auricle of the heart of the Hyla are so wonderfully thin that you can easily see the delicate individual muscular fibres and the finest nerve fibres distributed near to, and over and under them. Such thin tissue in its natural state is far better than any section that can be made, and if the extremely thin tissue is properly prepared and preserved in glycerine you can see all the different structures, and can make out distinctly the relation of the delicate nerves and their bioplasts to the muscular tissue, and can form some idea of the manner in which they act on the muscular fibres. You may in such a specimen work out a number of disputed points in connexion with the ultimate nerve network and its relation to muscular fibres and judge how it acts. These anatomical facts are of great interest and importance.

One cause of the difficulty in forming a conception of the changes which take place in living things generally arises from the misapprehension that every part of a living organism is *alive at any one moment.* This is a great mistake, for the greater part even of a single hair or feather for instance is as *dead* while yet connected with the living organism as it is after the severing action of a pair of scissors. The free end of a nail which is almost dry, is just as *dead* before it is removed by the knife as it is after the free portion is cut away from the rest of the nail. This is, of course, a rather important matter, if we bear in mind that a similar statement holds good with regard to the internal tissues of the body. Parts of the fibrous tissues, and many other tissues, such as the dentine and enamel of fully formed teeth, are just as far removed from the living state while they remain part of the living body as at any time after they have been removed.

Another source of confusion as regards "life" and "living" is the idea that the tissues of the whole living body are absorbed and removed in a certain moderate and definite period of time. We used to be assured that every part of us was removed and renewed once in each period of about seven years. Now that this is a fallacy is easily proved. The actual enamel of the tooth formed during childhood

remains the same enamel in the tooth of the adult. After enamel has been formed it is not "replenished" or renewed at any time. Or to take a still more striking instance—the tusk of the elephant; the whole of the tusk of this huge creature was in the early stage of its development and growth structureless, consisting entirely of clear, soft, colourless living matter. Indeed, if you were to examine the part near to the soft, highly vascular living tooth-pulp of the full-grown animal you would find in what originally were the so-called "cells," really in the form matter of the bioplasts, that minute particles of inorganic earthy matter were being gradually deposited, and as these increase, the soft living matter is slowly converted into a matrix which when impregnated with calcareous matter becomes the hard ivory. The outer oldest portion of the tusk of a living growing elephant may weigh 70 or 80 lbs., which in an old animal is non-living, though, of course, it is very firmly connected with the socket and the remainder of the "pulp" on the surface of which the continuous growth takes place. The greater part of the ivory of the tusk of an elephant one hundred years old is as dead, though the base is still firmly connected with the living animal, as when, long afterwards, part of it has been converted into billiard balls which may last for many years without perceptible change.

Connexion and disconnexion with the living body does not determine whether a given texture ought to be considered living or dead, but the fact of any matter being alive is proved by its "*growth*," a *living process*. The living matter which manifests this *power of growth* is invariably colourless, structureless, soft, and sometimes diffluent from the large quantity of water present in all matter that is alive, living matter that grows and changes quickly often containing more than 90 per cent. of water.

[The lecturer then explained his drawings and diagrams to the audience.]

Discussion.

The Chairman.—We shall be very glad to hear some remarks on this very interesting paper. It is one of the most fascinating subjects we can have to deal with, as well as one of the most difficult, if not *the* most difficult.

Dr. SCHOFIELD.—Perhaps I might ask a question of Professor Beale, viz., Whether he considers the nucleus of the cell to be living matter, and if so whether he considers it to be absolutely structureless?

Professor BEALE.—Yes, the nucleus, at any rate at first, is structureless, and some of the many changes depicted and described as occurring in the nucleus I think take place in consequence of some particles of the living matter *ceasing* to live. You may have bioplasm—living matter—without any nucleus at all, and under certain circumstances living matter may give rise to very many nuclei which appear *in its substance.*

The nucleus seems to me to be a new living *centre* which is evolved in the very substance of already existing living matter.

In reply to a question by a member of the audience regarding the distinction between certain actions of matter and of living organisms, the lecturer added:—My idea is that living *vital* power is distinct from all forces and energies. With regard to motion, it must be borne in mind that motion in living matter is one thing, and that other forms or modes of motion irrespective of life are altogether distinct. The motion of living matter has been called *spontaneous*—you cannot explain it. Then there is another point in which vital movement differs from every other kind of movement known. It is this, that in all living things the movement of the living matter is *independent of gravitation.* You might ask me to prove that. For instance, are not the particles of which a tree is composed lifted up one above the other often to a great height? It seems to me that this can never be explained by physical law. Newton, it has been said, made the great discovery of gravitation when contemplating the fall of an apple; but we microscopical people naturally ask, how was the scaffold raised—formed "bit by bit"—from which that apple fell? (Applause.)

The CHAIRMAN.—It was the result of the death of the stem that made the apple fall.

Professor LIONEL BEALE.—Yes, it was the weight of the *dead* matter of the apple that caused it to fall; but the living germ (bioplasm) wonderfully protected in the "seed" may, after having been some time in the damp earth, grow and form roots that grow *downwards*, and a stem that grows *upwards*, with leaves and branches, and at length flowers, followed by fruit containing year

after year many seeds, from which generation after generation of new apple trees may grow.

Professor E. HULL.—This being a purely biological question, I am unwilling to take part in it beyond making a few remarks. I apprehend that Dr. Beale holds and maintains that you cannot have life except from life.

Professor LIONEL BEALE.—Certainly.

Professor E. HULL.—I may remind you that some years ago, when this very question was being much agitated among men of science, attempts were made to prove, or to disprove, this great principle. It was attempted to show, or the reverse, that the amœba, or some form of microscopic structure, could be generated without contact with the air—which we know is full of organic vital forms—and it was asserted on one side that if in a certain preparation, such as a gelatinous preparation, organic living forms occurred, it was in consequence of contact with the air. The greatest care was taken to ascertain this point, and I think it was Professor Tyndall who carried out some experiments, and he came to the conclusion, which he announced, and I think Professor Huxley endorsed it absolutely, that it is quite impossible to produce life without the presence of some organisms already living. I think that is a point in which the lecturer thoroughly concurs.

Professor LIONEL BEALE.—Yes, that is assented to—that there is no such thing as *spontaneous generation*. That is settled for ever.

Professor E. HULL.—If this were a geological subject I should go on a little farther; but I do not wish to trespass.

Professor LIONEL BEALE.—That I think would much interest us.

Professor E. HULL.—I would refer to the fact that this world, as all geologists and physicists admit, exists as a mass which was once in a molten condition at a temperature in which life could not possibly have existed. There must have been a period at which life originated on the surface. Where did life come from? That is a question which Lord Kelvin endeavoured to answer at a meeting of the British Association in Glasgow, and we all know what the answer was.

Dr. SCHOFIELD.—I hope Professor Beale will pardon me, but I do not gather that he means that the nucleus and segmentation of sperm and so on is *post-mortem*.

Professor LIONEL BEALE.—No; but there are various appearances

seen in the nucleus, such as radiating particles and many geometrical figures, which I should maintain were not living.

Dr. SCHOFIELD.—Is the nucleus structureless when divided in that way?

Professor LIONEL BEALE.—According to my belief the only *living matter* of the nucleus is structureless. I should be very glad to have a talk with Dr. Schofield on this diagram, but it would, I fear, take too long a time to attempt to do so now. Every particle of matter that is alive I believe to be structureless, and the facts I have brought forward render this almost certain.

Canon GIRDLESTONE, M.A.—I think we owe a great debt to Professor Beale for giving us a lecture on this subject. It is not only a vital subject, but it is vital to us in many respects. First of all I thank him especially for discussing the use of words, for I think that half the quarrels in science and in theology and other matters hang on the use of words, and if we could only attach a definite meaning to every word we use we should have no broken bones. But we shall have to wait, I fear, until we get into another world for that. For instance, when a young lady refers to the state of her heart she is not at all thinking of these little particles of living matter connected with the muscles and nerves of the heart. She has quite a different idea. The Professor told us that we should not think too much of our hearts, but still we are liable to think of other people's hearts, or I do not think life would be worth living.

One idea struck me in regard to the word *Bios* in Biology. It is rather a mistake, I think, though it is late to alter it, that a distinction is not made between *Zoe*, which stands for the principle of life, and the word *Bios*, which stands, really, for the external condition of life. Perhaps I see it rather from the Greek Testament point of view, but *Zoe* gives the idea of the principle of life which we all feel, and concerning which we owe much to Professor Beale for his lecture. But if we could remember the difference between the conditions under which structure exists and that process or power, whatever you like to call it, which brings about those states of structure, it would be a great help to us in our discussions.

I sometimes think there is a difference between the process of construction and the structure which is its result. It seems to me that some of our scientific men have mixed the two, but

Professor Beale has always drawn a clear line between them. Supposing I said a lady was made up of a bonnet, a dress, a pair of boots, and a pair of gloves, I should have mistaken the things she had got on for the person herself, and yet it often happens that some of these minute things which we see under a microscope are spoken of as if they were self-constructed.

I might pursue my illustration farther and talk of a building making itself, but we know that buildings do not make themselves, and we have very high authority for saying that every house is made by someone. When a lady goes into a shop to provide these things, each of which is practically a construction of itself, she has an idea of what she wants, and proceeds to build up her external structure. She is the *Zoe*, the real agent by which all these various things are built up. She is the *Ego* which applies the matter in all its varied forms, and I think that has been especially brought out to-day with regard to the initial forms of life.

One other point struck me in regard to these little life particles. At first sight it would seem as if they were independent of one another, but Professor Beale brought us to think that we must go back to the origin and we shall find that all these little particles spring from one or at most a few, and thus you get at the true idea of the living growth, as contrasted with the crystal. Science speaks of an organic being as that life which proceeded from a centre and worked on a plan through and from that centre, growing in this direction rather than in that direction, until you get the true organic being. So after all, organization springs from life, and life springs from living organisms.

Professor ORCHARD.—I may express my thorough concurrence in what has been so ably put forward by Canon Girdlestone. We all thank Professor Lionel Beale very much for his kindness in coming amongst us this evening, and not least for drawing attention to that abuse of words which, as was observed, is often the cause of intellectual dissent.

John Stuart Mill called attention, I remember, to this practice of using words in different senses; he himself unhappily was not free from blame in that respect, though that must not be taken to lessen the value of his caution. The word *evolution* is a notable example; nor am I certain that Professor Lionel

Beale himself did not a little trip this evening when he referred to evolution going on in living matter. If that word is applied to the changes that living matter produces, or which are produced through living matter, the word is not used in its ordinary acceptation, for evolution implies the transmutation of species, and the transmutation of species I am sure Professor Lionel Beale would be the first to say was not proved by science.

I would ask the Professor, with regard to the conversion of non-living matter into living matter, whether he considers that it is *living matter* that effects that transmutation, or whether it is not rather *the vital principle* in that living matter which does so?

Professor LIONEL BEALE.—But the living matter is produced in the substance of existing living matter. It is here that the non-living matter introduced as the nutriment becomes living, and acquires from the already living matter itself vital powers of the same kind.

Professor ORCHARD.—Exactly.

Professor LIONEL BEALE.—And so in evolution I should say there is no example of evolution and transmutation dependent upon any changes except those which take place in the bioplasm —the actual living matter. You cannot have altered form, colour, and other specific changes in successive developments of creatures without every one of them beginning as living matter, which is structureless. You must consider the earliest stages to form an idea of the nature of the changes which result in the production of colour, structure, physical characters, chemical composition and properties.

Professor ORCHARD.—The word *development* would better express what I mean.

Professor LIONEL BEALE.—You have evolution in development, and may not development be applied to all forms of evolution.

Professor ORCHARD.—I should never myself use the word in that way. I think it is convenient to keep the word to a distinct theory which involves and postulates the transmutation of species. I do not think it quite answers the question as to the change of the non-living into the actual living matter. Is it not, rather, the vitalism, or the principle of life in the living matter which does this?

Professor LIONEL BEALE.—Yes; but the new matter becomes

part of the living matter which caused it to live. Let me say that, in discussing the actual phenomena of life, I have been led to consider what takes place at a point beyond that to which at present our sight can penetrate, though possibly our mind may "see."

Professor ORCHARD.—Quite so. But what effects the change?

Professor LIONEL BEALE.—Vitality—and then we must consider every change that occurs in the bioplasm, the only seat of vital action through nature.

As regards evolution, I should like to know something about the evolution of the bat, and particularly the nature of the transformations occurring at a very early period of germ life antecedent to the formation of tissues and organs and anything like a bat. But Professor Orchard's "evolutionists" do not explain even the evolution of his wings, and I donbt whether they have the least idea of the structure or mode of formation of the smallest portion of the thin membranous portion of the wing, to say nothing of the bat himself.

The CHAIRMAN.—I am only a chemist, and it has been the struggle of chemists to keep clear of biology; but biology invaded us. By adopting the word *organic* we thought at any rate we should be safe and that organs were living, and so we used the word to imply the structure of organisms, and then we found that chemistry was invaded by the result of formless organs; and so, with all our science, we find we cannot get away from this utterly mysterious problem that not even the whole of our bodies are living; but that minute fractions of them possess properties so marvellous that they take the entire bulk, both dead and living, out of the ordinary category of the non-living and make it a totally different thing.

Professor Beale has brought us face to face with the great problem of all others, and I think perhaps that some of us, though we may not use the Greek form, are obliged to confess ourselves in the living form *ignoramuses*.

Professor LIONEL BEALE.—Judging by Professor Japp's paper on "Vitalism" we are going to have much help from chemists before long.

Perhaps I might ask the Chairman whether it would be possible to organize a few meetings to discuss some of these questions amongst ourselves. It might be well considered by

the Council whether something of the kind might be carried out.

I have ventured to put some of my conclusions on slips of paper like these, and I think you will find that I am not likely to advocate anything that may be against the principles of the Victoria Institute. If so, I hope whoever may be in the chair will call me to account, and then I will give way.

The CHAIRMAN.—I can only say that as far as my vote is wanted in favour of such discussions it will most certainly be given. It is the discussion of these points that is the great desideratum.

I entirely concur with what Professor Beale said about words. Ambiguity causes great difficulty, and it is very important that words should have their definite meanings so that we may know how to fit them in.

The meeting then terminated.