ABSTRACT OF THE LUMLEIAN LECTURES ON LIFE, AND ON VITAL ACTION IN HEALTH AND DISEASE.

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Lecture II.

In his second lecture, Dr. Beale remarked that water must be very intimately associated with the particles of living matter. These cannot be regarded as dry solids suspended and moving freely in water; for every particle is composed of smaller particles in constant motion.

The most minute living particle consists of multitudes of living centres, and we may imagine lifeless particles forming among these and coming within their sphere; but it is not possible to conceive how atoms of particles of lifeless pabulum can of themselves separate and then become rearranged and acquire living powers. There must be a transference of power from the living to the non-living; and to this capacity of making alive there seems to be no limit; there is no loss on the part of the previously living particle by the repetition of the process. This, Dr. Beale believed, is the nature of the changes in the minute particles of bioplasm in all conditions—from the bacterium to man, in health and in disease.

New centres of living matter, such as nuclei and nucleoli, appear in pre-existing living matter; a second series may appear in the first, a third in the second, and so on; and the formative power of these series and of the bioplasts resulting from their division may be different. The centres from which matter inherits vital properties must be very minute—hundreds of times more minute than the smallest particle visible with a power of 5000 diameters; and they must be larger or heavier than the ultimate atoms of the component non-metallic element. It is absurd to speak of a *living atom*, and also of *dead* atoms of carbon, oxygen, or hydrogen: every particle of living matter must be composed of several elements, perhaps of multitudes of atoms of several different elements.

But it is not merely the power of moving from centres, of progressive movement, of transforming pabulum, of forming new and peculiar chemical compounds, that is acquired, but powers far more wonderful than these, by virtue of which the living matter produces living particles, generation after generation, from which definite organisms and definite and very different tissues in each single organism result. These powers are peculiar to the living world, and there are no forces, no behaviour of non-living matter, which can be said in any way to resemble them, or to exhibit the most distant analogy to them.

The time required for the transmission of powers from living matter to that which descends from it varies greatly. One particle may require weeks or months to acquire its full powers; another only a few days. The influence of temperature, food, and external conditions, is uniform only in the case of the same species. What the organism is, depends far more on what the organism was that produced it than on its food. The pabulum of tissues of complex animals is undoubtedly peculiar, and must be prepared before it is taken up; but how is it prepared? The bioplasm of the tissues selects pabulum from the blood, which is itself formed by bioplasm. Living matter takes up pabulum of the proper kind and grows, at last becoming formed matter, which constitutes the pabulum of other bioplasms, and this occurs several times before food becomes converted into tissues. If this conversion into living matter can be explained, or can be carried out in the laboratory, let it be done.

By admitting vital power, I am able to explain results without attributing metabolic influences to cell-walls, cell-contents, intercellular substance, walls of vessels, and other textures, which in reality are passive. I need not assume hypothetical actions and differentiations, or attribute to some hypothetical force, said to be akin to aggregation and crystallisation, phenomena which have not the faintest analogy with those processes; nor have I need to assume governing powers of which the mind cannot conceive, or matter-guiding forces acting in some unexplained way through all sorts of matter. Vitality acts in living centres upon matter only infinitely near the centre. This is all that is demanded by the terms of my hypothesis.

Dr. Beale then proceeded to speak of the conjectures advanced concerning the origin of life. The term "evolution", now supposed to solve the difficulty, has had at least two meanings. Some have restricted it to the living world; others have maintained that it should include not only the evolution of living from living forms, but the formation of the living out of the non-living. In support of the hypothesis of evolution in the latter of these two senses, facts are wanting, and the arguments adduced in its favour cannot have much weight. If evolution be restricted to the living world, the origin of the first living thing has still to be accounted for. With reference to this origin of the first living matter, several not improbable suggestions present themselves; in all of which, however, it is assumed that the change from the non-living to the living was sudden and abrupt, and not gradual. 1. We may conceive that one form of living matter was produced direct from the non-living, and that from this all future living was evolved. 2. We may prefer to imagine that more than one form of life originated from the non-living at or about the same time. 3. We might conceive that several different kinds of bioplasm originated in the beginning of an epoch of life, from which all life of that epoch was derived; new forms originating anew in the next epoch, the results of evolution from the first gradually dying out as those of the second epoch increased and became dominant. As life-epoch succeeded epoch, new forms of bioplasm may have appeared as old forms of life died out. These by no means exhaust the list of reasonable hypotheses concerning the origin of life.

Facts and arguments render it much more probable that the passage from the non-living to the living is sudden and abrupt, than that there is a gradual transition or scarcely perceptible gradation from one state to the other. This inference, however, is in opposition to the views of many authorities, and is opposed to the clearly expressed opinion of one of the greatest discoverers and most acute thinkers of the time, who maintains that the conversion of physical into vital modes of force is continually taking place.

Dr. Beale then proceeded to criticise the doctrine of spontaneous generation. The more accurately investigation is carried out, the more improbable does it appear that any living form should be derived from the non-living. I cannot, Dr. Beale said, but feel surprised that at this time many good reasoners should decide in favour of the *de novo* origin of bacteria. The modern advocate of abiogenesis should be skilled not only in explaining facts, but in explaining facts away. The fact that bacteria-germs exist in all parts of the higher organisms, in the most internal parts as well as upon the surface of man's body, is to be accounted for by their spontaneous origin! Although millions are to be found about the mouth and upon the surface, and it can be shown that it is easy enough for them to get from the outside amongst the tissues within, we are asked to believe that those inside originated there direct from the non-living, or, as an alternative proposition, that they were derived, not from parental bacteria, but by transmutation from some of the constituents of the tissues. What is required to settle the question of abiogenesis is well devised experiment. No resuscitation of old arguments and doubtful facts will avail anything in the absence of new experiments. The only view of spontaneous generation at all tenable is, that such minute organisms as bacteria are the only ones that can be formed anew, and that these alone, at any time in the world's history, sprang direct from the non-living. That multitudes do now spring from pre-existing forms is absolutely certain, for the process can be seen. Whether some spring direct from the non-living, is the question. Those that are supposed to be formed anew are very like those that have had a progenitor; and from those supposed to have been produced anew, forms exactly like those derived from undoubtedly pre-existing forms result. It cannot be pretended that new forms of existence are produced anew. No matter how the conditions are varied, the living forms supposed to result resemble known living forms, and give rise to forms of the same kind. The question of the origin of bacteria can only be determined by experiment; for the assumed *de novo* origin is contrary to what goes on through the whole kingdom of Nature. As regards the validity and reliability of the most recent experiments for and against the doctrine, I offer no opinion. If the formation of a bacterium-germ direct from non-living matter be possible, three very remarkable series of changes, as it seems to me, will have to be brought about. Whether any means will ever be discovered of effecting these changes, is most doubtful. First, the atoms of the non-living substances must be separated from their combinations. Secondly, the atoms will have to be rearranged to constitute groups of which the organic matter is made up. Thirdly, the groups of atoms must be made to live. What facts known render it likely that air, rarefied or condensed, or pressure of any degree or of any special kind, or any degree of heat, or light, or any conceivable modification of physical or chemical conditions, would, at the same time, account for

the pulling asunder and joining together of atoms, and for the conference of new and peculiar powers of growth, of movement, of division, and of the formation of new substances? It is not easy to conceive, in the imagination, the several steps which result in the formation of a living bacterium even from *organic matter*.

Commenting next on the absolute distinction between the living and the non-living, Dr. Beale said that reference had been made to facts and arguments which seem to justify the conclusion, that there are certain phenomena characteristic of all living matter, and which are included under the terms *nutrition, growth, formation, multiplication*—which are not physical, and which cannot be explained by physical law. These are *purely vital actions*, and ought to be placed by themselves in a class or category distinct from that of physical phenomena. No non-living bodies present phenomena which can be fairly said to correspond to, or to be comparable with, these. The vital actions of living beings are exclusively confined to the bioplasm or living matter. When this becomes converted into any kind of formed material, or when it suddenly dies, physical and chemical changes ensue which we are able to investigate.

There is yet another consideration to be advanced in favour of the doctrine of the absolute difference between living and non-living matter. In the non-living world every change is dependent upon, or is a consequence of, anterior change; and must, in its turn, lead to consequential changes. A real cause is not conceivable in the physical world, but I do not know upon what data the same could be affirmed with respect to the living world. Consider how the simplest vital action is to be accounted for. For instance, let us inquire what was the condition of the moving matter of a common amœba at a given spot just before the visible movement occurred. Who shall prove the nature of the antecedent to which the movement of the particles is a consequent? And who will demonstrate that the movement immediately following was a direct consequence of that which had been observed? In considering the nutrition and growth of the simplest living organism, such as the yeast-corpuscle, may we not conceive physico-chemical forces to be at work there to any extent imaginable, and yet fail to gain anything approaching to an adequate explanation of the facts discerned? Let it be admitted that in nutrition electro-chemical changes play an important, perhaps an absolutely essential, part. But will these or any other physical conditions account for the formation of the matter of the "cell-wall", or the increase of the bioplasm within?

Behind all the physical and chemical actions in living beings are the changes in the bioplasm by which alone the physical actions are rendered possible and their continuance provided for. Within every centre of every one of the thousands of minute molecules of living matter constituting every particle is a more central centre in which the matter is a degree nearer the point where it began to live, and where new powers were first communicated to it. The *cause* must be, so to say, very central; and in living matter the direction of the action of the forces is from, and not towards, centres. That forces in the environment react upon the force or power acting from the centre may be fully admitted; but that these are the *cause* of central activity, is clearly untenable. The central action is absolutely essential, and the difference between the matter in the centre, and the matter in the environment, is absolute.

The phenomena which I have described as characteristic of every kind of living matter in nature, and which are known only in connection with living matter, I must ask you to regard as purely *vital actions* due to the operation of a force or power capable of controlling matter and its forces, but neither originating in them, nor formed by or from them, nor capable of being converted into them—a power which we cannot isolate or physically examine, but the effects of the action of which we may study.

The next point adverted to was the construction of the body by bioplasm. After some preliminary remarks, in which the lecturer further criticised the doctrine of evolution, he proceeded to consider in outline the changes which occur when bioplasm, manifesting its wonderful developmental powers, at last gives rise to the formation of tissue.

The earliest state of matter, in every kind of development, is that of bioplasm, derived from pre existing bioplasm. The masses of living matter absorb nutriment, and the whole increases in bulk. So far, the only indication of formed material is afforded by the presence of a little soft transparent mucus-like matter, without any indications of any definite structure, accumulated around each mass of bioplasm. During the development of tissue, bioplasm-masses, embedded in their soft matter, continue to divide and subdivide. As development advances, there may be discerned amongst the bioplasts, here and there, one which undergoes more active change than the rest. This, in fact, becomes a new centre, from which growth proceeds, while the neighbouring bioplasts remain passive for a time, and some gradually waste. Soon, by division and subdivision, a collection, composed of a new series of bioplasts, results. Many such collections are formed, being separated from one another by the altered bioplasm particles of the previous generation, and their imperfectly developed formed material. Thus result the first indications of the structures and organs in the embryo at a very early period of development. The process is repeated many times, probably ere the first traces of actual structure with capacity to act are to be detected. Nay, the tissue which is at last formed, and which acts, exhibits structure, but this first tissue is only temporary, and differs in its characters from the permanent texture which is at length formed. Thus, the first muscular tissue which is produced in the mammalian embryo only lasts for a short time, and it is entirely replaced by a form of contractile tissue, which differs materially from it in structural arrangement and in mode of growth. The formation of cartilage, bone, nerve-tissue, glandular and other organs, illustrates the same fact.

But formed material results from changes in bioplasm. The production of formed material may be studied in the early development of any of the tissues, and, in many of them, at any period of life. In all cases, the newest formed material is that which is nearest to the living matter. This formed material is pushed out, and a more recent formation occupies the space between it and the bioplasm. Gradually the formed material loses water, becomes firmer, and slowly undergoes other alterations, until it assumes its characteristic form and begins to fulfil its proper function. In some cases the bioplasm actually moves onwards, leaving the formed material, which it has produced, behind it. This phenomenon occurs in certain forms of yellow elastic tissue and muscle.

However long a period may elapse before the formed matter assumes its characteristic peculiarities and becomes functionally active, its characters, its properties, and its chemical composition mainly depend upon the changes which occurred just at the moment it ceased to be bioplasm, the time when they assumed the condition of formed material. If we desire to discover the true cause of the formation of tissue, we must search for it in the bioplasm ere formation occurs. According to my idea, there is something operating in each kind of bioplasm which in fact determines the kind, by virtue of which the living matter must grow and must produce formed material of a certain character, if only it be supplied with pabulum, and be placed under certain conditions. This something is, I believe, a power or force which the bioplasm has derived from pre-existing bioplasm. Conditions may indeed modify the action of this power within certain limits, or may prevent its action altogether; but that the action results from the power, and ought not to be attributed to the conditions, is obvious from the fact that one form of bioplasm exposed to the conditions favourable to the developmental phenomena belonging to another kind, will not be so influenced as to exhibit these.

The characters of previous generations are indelibly stamped upon every individual belonging to each generation, and these inherited characters can be transmitted by the bioplasm only. Those peculiarities of external form, and of external and internal structure and action, in which one species differs from all others, must also be attributed to the vital phenomena of the bioplasm. In like manner the power of origination, and handing down of newly acquired properties and characters, is limited to bioplasm. Bioplasm is the agent concerned in the transmission of all hereditary structural peculiarities. There is nothing in the non-living world that presents any analogy with this marvellous power of inheriting from predecessors definite characters, and transmitting them to those that succeed. All will accept Mr. Darwin's conclusion, that, whenever variation occurs, the cause of variation must be attributed to something in the "nature or constitution of the organism",—or, as I venture to think, we may say with still greater accuracy, to something in the nature or constitution of the bioplasm from which the organism is developed. This cause of variation must, as it seems to me, be very closely related to the cause of the formation of tissue by bioplasm, and is in its nature *vital*—not *physical*.

The early changes in development require a considerable *time* for their completion, but the laws by which varying rates of growth in different living forms are governed or determined have not been discovered. Although wonderfully little pabulum is taken up, and but a small quantity of matter undergoes change, phenomena of paramount importance proceed, and time is very necessary for the completion of these early changes in all organisms, and especially, of course, in those that are complex. In vegetable organisms, the time that must elapse between the completion of the formation of the seed and its germination varies very much, as also the periods of time during which the seeds of different plants will retain their vitality, and this must depend upon inherent properties of the bioplasm. So also, with respect to the periodical rests from growth, the greatest individual differences are

noticed. Inherent vital peculiarities also manifest themselves in cases in which a moderate rise of temperature is far more damaging to the vital phenomena of the normal bioplasm than a corresponding fall. If the average temperature be a little above or below that which is adapted for the growth and development of certain creatures, the organism soon begins to suffer; and many tissues, although they may be formed, never attain the most perfect construction possible, or their highest functional activity, and probably they begin to deteriorate long before those of corresponding organisms which are developed under the particular conditions suited to their special vital phenomena. Is there not something very remarkable in the fact of the existence of powers or properties in the several kinds of bioplasm, by virtue of which, each seems to grow and flourish only within its own particular range of temperature? We cannot even lay it down as a law that a low temperature is necessarily destructive of vital action, for there are organisms which flourish at or below the freezing point of water. In short, the various forms of bioplasm have their individual peculiarities and characteristics, which they inherit, and may transmit, and which are not to be accounted for by physics, and which seem in truth to belong to their constitution. Conditions which are life to some forms of bioplasm are death to others.

Some are content to be assured that peculiarities from time to time originate, and that their fortunate possessors gain thereby great advantage, so that they are enabled to overcome their less fortunate brethren, and even to utterly exterminate them. Being the fittest to live, the few soon predominate. Bioplasm, with the newly acquired properties, transmits the peculiarities to that which descends, until bioplasm, capable of producing an organism still more fit, somehow results. The organisms derived from this then prevail, and enjoy the advantage of living and continuing the race. So the experiment is supposed to proceed.

ON THE ACTIONS OF PICROTOXINE, AND THE ANTAGONISM BETWEEN PICROTOXINE AND CHLORAL HYDRATE.

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(*Concluded from page* 507.)

To give greater completeness to the inquiry into the antagonism between picrotoxine and chloral-hydrate, it was judged advisable to test its existence in another class of animals besides rabbits and guinea-pigs. A few cats were, therefore, obtained, and to two of them picrotoxine alone was administered, in order to ascertain its unmodified effects.

Experiment LXXXIX.—Cat, weighing 4 lbs. 13 oz. The cardiac pulsations were 120, and its respirations 36 per minute. Under the skin of its back, one-sixteenth of a grain of picrotoxine was injected, at 12.10 P.M. An almost immediate effect was observed. At 12.15, the respirations were 48 per minute, and much fuller and deeper; there were incessant licking of the lips and slight shakings of the head. At 12.17, saliva was dropping from the mouth, and there were dulness and stupidity. At 12.19, the flow of saliva was very large, and the eyes were being constantly opened and closed. At 12.21, the blinking of the eyes continued, and there were restless movements of the ears, while the animal was dull, and not readily roused. At 12.23, the saliva, which at first dropped from the mouth, had become so viscid that it hung in long wreaths, reaching from the lips to the table on which the animal sat, blinking both eyes vigorously. At 12.25, the bowels acted freely; the respirations were at the rate of 180 per minute. At 12.27, there were slight twitchings of the eyelids, ears, and cheeks, most pronounced on the left side. At 12.29, these twitchings continued, and were more severe, while enormous quantities of viscid saliva flowed from the mouth. At 12.31, there were occasional violent startings of the head; the animal was more easily alarmed, and any loud noise caused the ears to be drawn back and flattened. The respirations remained at 180 per minute. At 12.33, the slight twitchings of the eyelids, nose, and ears were continuous, while, every thirty or forty seconds, there were more general and severe startings. Saliva still flowed in excessive quantities, and the pupils were dilated. At 12.35, the severe startings recurred every thirty seconds, and were seen to consist in a sudden movement, forwards and downwards, of the head, with stretchings of the neck, and in raising of the shoulders. The movement altogether recalled that which is made by a cat when voraciously chewing and swallowing a rather large morsel. At the same time that the head was pushed forwards, the ears were drawn backwards and downwards. Intermediate between the more violent movements, slight twitching, particularly in the eyelids, causing blinking, continued. The animal remained in a sitting position, and was drowsy; its pupils were widely dilated, and saliva still dribbled copiously from its mouth. At 12.40, no change had taken place; but, at 12.50, there were twitchings of the left fore-paw which was first stretched out, then raised in the air, and subjected to clonic spasms; respirations 138. At 1.5, the twitchings were less incessant and severe, and, at 1.15, they ceased altogether. At 1.20, the flow of saliva was much diminished, and the animal was more lively and able to move about, the respirations being then 60 per minute. At 2.15, the animal was in all respects recovered.

Experiment XC.—A large cat, weighing 6 lbs., had one-fourth of a grain of picrotoxine injected at 2.20 P.M. An instantaneous effect was noticed; the animal was restless, and in two minutes saliva began to drop from the mouth. At 2.24, there was loud mewing, and the head began to shake. At 2.25, there was emprosthotonos; the head was drawn down, until the forehead was pushed against the table, and the back arched upwards, while there were violent general startings. At 2.26, after several attacks of emprosthotonos, the animal tumbled on its side, when its head was suddenly drawn backwards, and its pupils were dilated to their widest possible extent. The fore limbs were stretched out, and the toes and claws were expanded, but the hind limbs were drawn up and remained in a flexed position. There was violent working of the mouth which was surrounded with foam, as well as twitching of the nose, eyelids, and ears. There were also severe spasms of the fore limbs. Several times the animal endeavoured to get on to its feet, but was unable to do so. At 3.32, the head was drawn down between the legs, and the back was arched upwards, the fore limbs were semiflexed, and the toes and claws folded in; the ears, eyelids and brows were in constant movement, the tongue was being constantly protruded and drawn back into the mouth, and it, as well as the lips and mucous membrane of the mouth, had a livid colour. The pupils were contracted to mere slits, and the animal was apparently unconscious. At 3.36, the clonic spasms were interrupted for a little, when the pupils at once dilated, but, at 3.38, they recurred, and then the pupils became once more contracted. From this time, however, the clonic spasms were much less severe. At 3.42, there were constant slight twitchings of the upper lip, eyelids, ears, head, and paws, with low moaning sounds. At 3.47, there were momentary intervals between the discharges, and in these intervals the pupils dilated slightly, always contracting again with each fresh discharge. At 2.50, the animal died, when the pupils at once dilated widely.

The action of picrotoxine upon the cat, as exhibited in these experiments, did not seem to be very dissimilar to its action upon rabbits and guinea-pigs. Increase of the salivary secretion and of the peristalsis of the bowels, hurried respiration, tonic and clonic spasms, with coma, were all included in its effects. One of its effects, however, that upon the pupil, was more distinctly manifested than in the other animals named. It first enlarged and then diminished the size of the visual aperture, and it should be noted that the dilatation was synchronous with opisthotonos, the contraction with clonic spasms. I have remarked that in cats, in which the movements of the iris are very easily observed, toxic agents invariably induce contraction of the pupil contemporaneously with clonic spasms and dilatation of the pupils with tonic spasms. The phenomena of absinthe, strychnia, and opium-poisoning in cats, will afford verification of this statement. Sometimes, during clonic spasm, the pupils may be seen contracting with each discharge, and dilating during each interval; so that, if the discharges succeed each other very rapidly, the irides have an oscillatory motion. I think I should be justified in saying, that the dilator muscle of the iris ought to be grouped with the extensor muscles, which are generally predominant in action in acute tonic spasms, and its sphincter with the flexor muscles, which predominate during clonic spasms.

The similarity which was demonstrated to exist between the effects of picrotoxine as seen in the cat and those observed in the rabbit and guinea-pig, gave good grounds for anticipating that chloral-hydrate would control those effects as conspicuously in the former as it did in the latter animals. No misgivings of the result were, therefore, entertained when the following experiment was undertaken.

Experiment XCI.—Cat, weighing 5½ lbs. At 2.54 P.M., one-fourth of a grain of picrotoxine and twenty grains of chloral-hydrate were simultaneously injected. At 3.7, the animal was restless and uttering low cries. At 3.13, it was drowsy, and mewing occasionally. At 3.15, there was a severe fit, in which the fore legs were spread out and the head was shaken, the ears being folded backwards, while there were also violent general startings. At 3.20, the cat died suddenly without any further convulsions.

The termination of this experiment was unexpected and somewhat