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With the Author's Comments

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A BRIEF PAPER
ON THE
PATHOLOGY OF INSANITY,

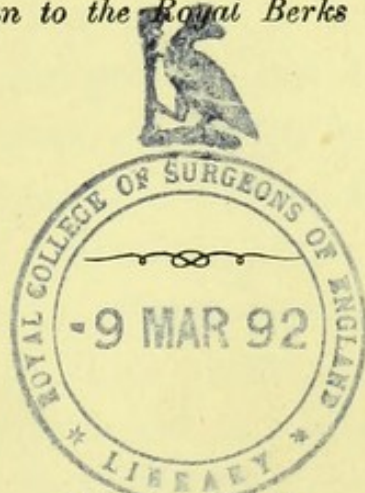
READ AT A

MEETING OF THE READING PATHOLOGICAL SOCIETY,
HELD AT THE ROYAL BERKS HOSPITAL,
WEDNESDAY, MAY 26TH, 1869,

BY

R. C. SHETTLE, M.D.,

Physician to the Royal Berks Hospital.



READING:

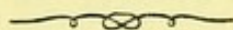
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The Pathology of Insanity.



GENTLEMEN,

Having been requested by the President of "THE READING PATHOLOGICAL SOCIETY," to bring forward some subject for Discussion, I have much pleasure in acceding to the request, and thus doing what I can to further the objects of the Institution. Not from the idea that I can in any way add to the knowledge of any one present, but because I consider there are few diseases so perfectly understood, that they may not be capable of having fresh light thrown upon them by free discussion, and a consideration of the opinions of those whose experience has already been made known by their writings.

Selecting a subject was the first difficulty with which I had to contend in carrying out the proposal, but my friend, MR. HARRINSON, very kindly suggested, that as MR. WALFORD'S Paper on a case of Puerperal Insanity had been somewhat discussed, it

would be as well to carry on the subject by entering on the question of Insanity generally.

I have, therefore, made an attempt to collect as many facts as I could with regard to the pathology of the disease, and I trust the vast importance of such a subject, will plead my excuse for endeavouring to open up so wide a field of enquiry, in the small space of time that can be devoted to any one question, at a meeting like the present.

Before attempting to describe a disease, it appears necessary to define, as clearly as possible, what constitutes health. In as concise terms as possible, I would describe a healthy mind as that state of the brain, which, existing in any individual, enables him, by a free exercise of the will, to grasp some mental thought or idea; to study some subject which requires considerable exercise of the imagination as well as of the reasoning powers of the understanding for a considerable time, without wearying its powers; and I would further add, a capability of fixing the attention upon any one subject, or turning it to another at will. DR. BAIN, in his valuable work, on "The Emotions and the Will," says, at page 412, "Could we suppose an instance of great emotional character, as displayed in the sustained vehemence of outward demonstrations, an intellect unusually strong in the elements of mental reproduction, and a will keeping in subjection alike the one and the other, we should have to pronounce that will, something almost superhuman." And concluding the happy possessor of such a state of the reasoning faculties to be endowed, not only with a healthy, but also an educated mind, and

taking such for a standard of what ought to exist in health, we are able to arrive at a tolerably accurate idea of what constitutes disease.

I propose first to consider the various morbid appearances that have been found in the brains of those who have died insane; after the consideration of which, I shall endeavour to connect the symptoms with the evidences of diseased action, and subsequently divide those unfortunate victims of disease into two classes; viz:—those in which the disordered action of the brain arises from great shocks to the nervous system, and those in which it originates from some primary blood affection. First, with regard to the morbid appearances found after death. DR. HASLAM says, that in thirty-seven out of thirty-eight dissections of the brains of those who have died insane, he found the pia mater and arachnoid hardly ever sound, with adhesions to the pial glands, and softening of the central parts, and he infers that madness is always connected with disease of the brain or its membranes. He is supported in his opinion by Drs. GREDING, J. WERZEL, of Mentz, CHIARUGI, of Florence, and M. BAYLE. MORGAGNI, from an extensive course of dissection of the brain of these unfortunate individuals, states that in some cases he found the brain harder, and in some softer than normal, occasionally that the dura-mater was thicker and more studded with soft whitish bodies on the sides of the longitudinal sinus, and the sinuses themselves sometimes evinced polypous secretions, and the pineal gland, or several of the glands in the plexus choroides were in a diseased state. MECKEL found the brain harder and denser

than usual. Dr. SMITH described a bony concretion, and PLENZIG and several others represent it as bony or calculous in various points, whilst JONES describes it in his Medical Commentaries as softer than usual, with a thickening of the membranes and a turgescence of the vessels. Dr. FORBES WINSLOW says, "There can be no doubt entertained by those who have had practical opportunities of observing the various phenomena of mental derangement, that in many instances the disease clearly arises from a state of active capillary congestion on the surface of the hemispherical ganglia, or in the vessel ramifying over the membranes, immediately in contact with them, and of this we have proof in the alterations of structure so frequently observed after death, in the internal table of the skull, dura-mater, pia-mater, tunica arachnoid, and the fibrous as well as vesicular structure of the brain." But in addition, he says, "He has often been surprised when examining the heads of those who have died from the effects of *acute* insanity, at the absence of even an approximation to an adequate physical cause for the mental disorder; and such types of insanity must be either connected with subtle changes in the vesicular neurine, of which we at present have no knowledge and which are not even appreciable by the microscope, or *arise from an altered condition of blood, nerve force, or chemical constituents of brain matter.*" Drs. BUCKNILL and TUKE in their volume of Psychological Medicine do not appear to have been able to detect with the microscope any change in the size, shape, or proportional number of cells, exudation or addition to the inter-

cellular substance of those who have died of the malady, but mention that they have found in the atrophied brain of the insane, quantities of those bodies which bear so close a resemblance both in form and chemical reaction to starch corpuscles. Small plates of cholesterine they state are not uncommon in degenerated brain tissue, and further say, "we have frequently observed peculiar bodies which we have nowhere seen described." They are in shape like the blade of a lancet, pointed at both ends, and about three or four times the width of a nerve tube. DR. SANKEY gives some microscopic appearances of the brain in which he shows a hyaline substance formed round the vessels. In other cases, the vessels themselves are more or less tortuous in their course, and in some instances so tortuous, as to require some very careful manipulation to prevent the tortuosities appearing like aneurismal enlargements on the calibre of a single vessel.

MR. J. LOCKHART CLARKE says in a Paper he published in "The Lancet" of September 1st, 1866, on "The Morbid Anatomy of the Nerves and Centres in General Paralysis of the Insane," that "On comparing vertical sections of the convolutions of a healthy brain, with those of a brain of a person who has died of general paralysis, a striking difference between them is often observable even to the naked eye. In the latter case, a series of streaks or lines may frequently be seen radiating through the white and grey substance towards the surface; and in vertical sections of convolutions that have been hardened in chromic acid, it is very common to perceive in the white sub-

stance especially, what seems at first sight to be a number of vertical fissures and oval slits, which under the microscope are found to contain blood vessels, surrounded by sheaths, but the sheaths in these cases are often less delicate; they are thicker, more conspicuous, and frequently darker than in the healthy brain; and sometimes, especially when the vessels are convoluted, they appear as fusiform dilatations along their course. Moreover, while in the healthy brain the granules or grains of hæmatosin are commonly scanty, and frequently absent altogether, in general paralysis they mostly abound, being scattered in some places and collected into groups in others. In the nerve cells of the convolutions, I have frequently discovered certain structural changes, which, as far as I am aware, have not been mentioned by other observers. These changes consist of an increase in the number of the contained pigment granules, which in some instances completely fill the cell, in other instances the cell loses its sharp contour, and looks like an irregular heap of particles ready to fall asunder." The alteration in the floor of the fourth ventricle spoken of by MONS. JOIRE, and described by him as similar to the elevations produced on the skin under the influence of cold, MR. LOCKHART CLARKE says he is quite familiar with, and says, "It is due to hypertrophy of the ordinary epithelium by which the ventricle is lined, and under a high magnifying power the granulations or eminences are seen to consist of globular aggregations of the ordinary epithelial cells, which, in a natural or healthy state, are arranged side by side, and form a smooth or level surface."

I may also draw attention to the fact that there are many authors who have paid considerable attention to these matters, who attribute the affection to inflammation of the coverings of the brain; amongst whom I may mention the names of PINEL and MARSHALL HALL. DR. CONOLLY ascribes it to corporeal diseases, in addition to the diseased action of the brain itself. COX, ARNOLD, and PARRY, ascribe it to determination of blood to the head. CULLEN considered it arose from some irregularity in the action of the brain or nervous system, caused in the majority of cases by cerebral excitement. SIR ALEXANDER CRICHTON believed that insanity was caused by a specific morbid action of the vessels that secrete the nervous fluid, affecting not only the quantity, but the quality. So much for the evidences of diseased action. I think it will be well now, to consider the general character of the symptoms of inflammation of the brain as they have much bearing upon those existing in insanity. They run somewhat as follows,—pain in the head, which may be only slight, or may amount to intense headache, redness of the face, suffusion of the eyes, an excited or wild expression, giddiness, buzzing or roaring in the ears, and painful sensitiveness to light and sound, especially the former, so that the eyes are often closed forcibly, and the pupils, when they are open, are seen to be contracted, sometimes almost to a pin hole in size; there is also extreme restlessness, jactitation and want of sleep, with convulsive and spasmodic movements. The pulse is frequently hard, and sometimes irregular or tumultuous, and the respiration is hurried, skin hot, and sometimes moist,

whilst vomiting frequently attends from the commencement, alternating occasionally with the pain in the head. Now all these symptoms are unquestionably those which indicate exalted action, and as natural action is dependant upon an equable circulation through the brain, we have proof that here, the circulation must be *in excess of the natural amount*. We next come to a train of symptoms which indicate that excessive action is tending to produce disorganization, and one of the earliest symptoms of abnormal action of this character, is an incapability of controlling, or exercising the mind, hence we get in acute inflammation when there is so much disturbance to normal action, delirium, which may be of two kinds, viz :—that which is characterized by incessant and incoherent talking, the mind flying rapidly from thought to thought, and in which it perceives unreal sights, sounds or odours, and other symptoms of the like nature, or it may be of a low form with frequent mutterings, and unaccompanied by little, if any, of that violence which is a characteristic feature of the former variety.

As bearing upon this matter, I shall again quote from the volume of DRS. BUCKNILL and TUKE, as follows ; “ We know that if that dominant nerve mass, the brain, is not supplied with a due amount of plasma from the blood, or if plasma be supplied to it containing noxious substances, such as urea, or narcotics, or if it is subject to pressure, or over stimulated, or if deprived of due repose, its functions are interrupted or perverted, and further they state that the one physiological principle upon which we have to

build a system of cerebral pathology is, that mental health is dependant upon the due nutrition, stimulation, and repose of the brain, that is, upon the condition of exhaustion and reparation of its nerve substance being maintained in a healthy and regular state, and that mental disease results from the interruption or disturbance of these conditions." I also quote a passage from "Fletcher's Pathology," page 432, which also bears particularly on this subject; it runs thus, "The faculty of thinking is for the most part under the same circumstances as sensibility is, so as in second stage of fever and arachnitis of the surface of the brain, whereas it is too obtuse under opposite circumstances, as in the first stage of fever, and in nervous apoplexy on the one hand; and in arachnitis of the ventricles of the brain in encephalitis and sanguineous apoplexy on the other. It is obvious that under the former circumstances there will be a greater accumulation of blood about the grey matter of the brain, and under the latter a less quantity than usual, and as the deposition of nervous matter may be presumed to be *ceteris paribus* proportioned to the quantity of blood in the arterial capillaries, it must follow, that in the former case there will be an increased, and in the latter a diminished deposition of grey matter of the brain, the immediate seat of the faculty of thinking. In these last instances the diminished deposition of grey matter seems to depend upon an increased deposition of white, which stands probably to the former in the relation of ducts alone. But as the brain collectively taken is an incompressible organ, contained within an

undilatable cavity, it follows that if there be too much blood in the white, there must be too little in the grey ; that in fact the white fibre now exercises a pressure upon the grey, almost equivalent to that produced by the depression of the bones of the skull, except that the pressure is from within instead of from without, and hence it is easy to understand how too much blood in the central part should render the thoughts dull, as how too much blood about its surface should have an opposite effect. It is only in this way that we can explain how too much blood in the brain, collectively taken, should give rise at one time to increased vivacity of thought, as in arachnitis of the surface, and in the hot stage of fever, and in another to perfect sopor, as in sanguineous apoplexy." It will be seen from the above, that DR. FLETCHER having referred the mind to the healthy action of the grey matter, attempts to prove such is the case, and I think you will agree with me, Gentlemen, that his reasons for his conclusions are satisfactory, for as he very justly remarks, in arachnitis, when there is an increased flow of blood to the membranes of the brain, especially there we get considerable vivacity, until, as I have before pointed out, the increased and abnormal action has given rise to a certain amount of disorganization. Recent researches indicate the existence of a very remarkable and complex apparatus of cells in the cortex of the cerebellum, most resembling the basilar layer of the retina, and which VIRCHOW thinks very likely stand in some close connection with the psychical functions.

The chief difference that appears then to exist

between a genuine attack of inflammation of the brain or its membranes, and an attack of insanity, or rather that variety which we are now more especially considering, and not that form which kills rapidly and leaves scarcely, as is supposed, a trace behind, is one of degree, for insanity comes on for the most part very insidiously, so much so indeed, that it cannot be estimated when diseased action first commenced, but inflammation on the contrary attacks the brain suddenly, by injecting a much increased quantity of blood into the capillaries, of some portion of the brain or its membranes, giving rise to a corresponding degree of exalted action, and all the ordinary symptoms which accompany increased vascularity. Having thus far imperfectly traced the connection between an attack of acute inflammation of the encephalon, and an attack of insanity, I would next endeavour to point out the special causes which operate to give rise to the latter malady, and, although they are numerous, I believe they may all be said to have their *origin* in a *previously vitiated state of the blood*, with the exception, perhaps, of that variety to which I have referred. In proof of this, I shall make no apology for troubling you with a quotation from "FEUCHTER-SLEBIN's Medical Psychology," as he gives some very interesting experiments on the transfusion of blood, which have a remarkable bearing in my opinion on this point. He says, "That it falls within the province of physiology to show how the blood affects the action of the nerves, and thereby acquires psychical importance. We here rest on the facts before us; probably the most important of these are the results

of transfusion, tried first experimentally upon animals ; these observations afforded only very uncertain results, because the want of speech in animals, always left doubt respecting the nature of the change that had taken place, and the physical functions of animals do not admit generally of a well founded comparison with those of man. Yet wilder animals, into which the blood of tamer ones had been transfused, showed themselves to be more timid, and on the other hand, older animals into which the blood of younger ones was transfused, to be more lively and active. The experiment on man in a state of sickness seemed to be more important. The patient on whom DENIS made the first experiment of transfusion in the human subject, who had wholly lost his memory, and was affected with great indolence and drowsiness, became much more lively, and his indolence vanished ; his second patient, prior to the operation, lay in a state of lethargy, accompanied with occasional convulsions, but after the injection of some calf's blood, gave every possible proof of active consciousness. The third patient was cured of insanity by transfusion, and the fourth of paralysis and mental debility ;" and the learned Baron goes on to say, "That the repletion and increased action of the vessels, stimulate to activity by the centripetal nervous filaments, which encompass those vessels and heighten thereby the facilitated physical affections and re-actions, which in the lower degree manifest themselves in cheerfulness and courage ; in the higher in arrogance. Increased plasticity and predominant arterial action lead to the same results, both, however, only to a certain degree, beyond which oppression en-

sues. Vacuity and a relaxed condition of the vessels produce, by a sinking of the nervous power a contrary effect similar to the tone of mind, which exists after venesection and considerable loss of blood." He still further asserts, "That a corrupt state of the blood, whether it arise from a spasmodic, miasmatic, contagious, or any other cause, has the effect of depressing the spirits. The spleen of the English is partly attributed to an endemic influence of this kind, which corrupts the blood through the atmosphere. Among the dyscrasies the gout especially acts on the mind through the brain; among the cachexias it is scurvy." I must also give you another quotation from Drs. BUCKNILL and TUKE, who say, "That the ultimate conditions of mind with which we are acquainted being the due nutrition of the brain cell, it is of the utmost importance to have a clear idea of the manner in which this is effected. The grey substance of the human brain contains millions of vesicles lying in a semifluid granulated substance, (stroma) and bound together by a minute net-work of capillary blood vessels and fine areolar tissue. Now the fundamental truth of physiology being the activity of the cell, and this activity being accompanied by its decay and demanding its renovation, the mark-worthy points in the relative position of the brain cell are, first, its relation to the nerve tube from which it receives, and to which it conveys impressions, the taking and giving of which are the causes of its exhaustion; second, its relation to the blood capillary, which exudes a plasma, in which the cell is bathed and renovated, and from which new cells are formed

to replace those (if such there be) which are finally exhausted." They also further observe, "That the broad view of the production of insanity appears to be this; the brain, like every other organ of the body, for the perfect performance of its functions, requires the perfect condition of its organization and its freedom from all pathological states whatever, consequently the existence of any pathological state in the organ of the mind, interrupts the functions of that organ, and produces a greater or lesser amount of disease of mind, *i. e.*, of insanity."

It will be seen from the above, that I am by no means singular in arriving at the conclusion that a vitiated state of the blood has an immense influence in producing insanity, and could the limits of these remarks, as well as your patience, be regarded as sufficiently elastic, I might give numerous other quotations tending to show the same thing, but to me it appears that such would be unnecessary, for having once regarded the disease in such light, it is difficult to look at it in any other, for we all know the extreme delicacy of nerve fibre, and it must be evident to every physiologist that, *provided the fluid from which the nerve fibre is built up, is not pure in itself, the superstructure must partake of the impurity, and any impurity of the axis cylinder, must inevitably, more or less, retard the transmission of impressions, for those impressions must be dependant upon the vital force, and let that force be, of whatsoever it may, still as force it depends upon motion, and as the rapidity with which nerve force travels is very great (HELMHOLTZ estimates it at somewhat more than*

two hundred feet per second,) anything that tends to intercept that force, or motion, must be a means of producing friction or heat, in a degree corresponding with the amount of impurity existing and force transmitted, and thus we should have in the *materies morbi* deposited in the living structures from the blood, mechanical causes for the production of disease.

Upon this point, also, I shall quote largely from that valuable volume of DRS. BUCKNILL and TUKE already so freely used. They say, "All disease therefore in our opinion is organic, not a thrill of sensation can occur, not a flashing thought, or a passing feeling can take place, without changes in the living organism, much less can diseased sensation, thought, or feeling occur without such changes,—changes which we are not able to detect, and which we may never be able to demonstrate, but which we are, nevertheless, certain of. For whether we adopt the theory that the states and things which we call heat, electricity, vitality, &c., are distinct entities, or what is called imponderable matter, or the far more probable theory that they are only phenomena belonging to ordinary matter, an atom or a cell charged with electricity or heat, or in a state of chemical activity, is essentially in a different condition to a cell or an atom in chemical or electrical *equilibrium*, with surrounding substances on the lowest view of organic action, therefore, alterations of what are called dynamic forces cannot exist without corresponding changes in material condition. It is possible to suppose that the cells of a living structure in a state of disease, can only differ from the cells of the same structure in a state of health, by an alteration

in their electric states, this will, in itself constitute a material difference capable of being re-adjusted by appropriate remedies. Although it may hereafter be proved that all forces are not merely correlated, but identical, there is as yet small ground for supposing that vital force and electrical force are the same, or that anomalous action of living bodies ever depends upon the mere distribution or activity of such force. The only force, say these Authors, capable of explaining any of the phenomena of life, is the chemical one, and this only in a state of constant activity and interminable change. I cannot help remarking here, and I do so with all deference to the opinions of the Authors quoted above, that there are many reasons why the *electrical force* should be the primary agent in producing the phenomena of life. It is true that the *one* force cannot be developed without the other, but it is much more easy to produce a manifestation of electrical force, than to obtain evidences of chemical action.

But there is another aspect in which to regard the action of the vital force upon the brain, which ought to be considered before entering upon the varieties of blood disorders, which are calculated to promote specific forms of mental disease. Thus it is admitted, I believe by all, that the blood is the source of the vital action, or the vital force, and admitting the blood itself to be disordered or diseased, the force arising from it would be altered also, and with the nature or amount of the force passing from the blood to the nervous system, we should have either excessive or defective supply of nervous force as well, and a

corresponding derangement of all the functions of life. In the one case there would be morbid irritability of the senses, with craving appetite, increased powers of digestion, and increased tone of the muscular and mental systems, whilst the other would be marked by a general state of languor and lassitude of the whole body, and an inability to exert the muscular and nervous systems for any length of time. It is true that in either case we should be likely to get morbid sensations and impressions; but it will be easily understood, why in the one case they should be characterized by rapidity of thought and motion, and incoherence of speech, and in the other by feeble powers of the muscular system, and indeed of all the vital actions. Having given this brief outline of the mode in which disorders of the blood may affect the nervous system generally, I would call more particular attention to some diseases of the blood, which have a peculiar influence over affections of the brain, and will first allude to gout, and quote a short passage from MR. HARRINSON'S valuable paper on "Disease in general and pathology in particular," read before this Society in 1855. MR. HARRINSON quotes a passage from the "Edinburgh Medical and Surgical Journal" for Jan., 1854, from a paper on "Gout as a blood disease" by DR. BEGBIE. "Gout" says DR. BEGBIE "is a blood disease, and may disclose itself in every organ of the body, and complicate and involve every disturbance of the system; it may visit every part and texture, from the crown of the head to the sole of the foot, and molest and vitiate every function pertaining to life. We discover it in the head, where, not unfrequently in

the form of intense headache, its first manifestation is perceived. We trace it in fits of giddiness and in transient affections of sight and hearing, and often we are called to acknowledge its presence in apoplectic and paralytic seizures, and its most intimate association with lethargy and coma, in connection with serous effusion, or other cerebral diseases : we discover it in the spinal sheath or spinal marrow in the shape of paraplegia, and in every part of the nervous system in the form of neuralgia.”

This very graphic description of this well-known disease, makes it unnecessary for me to quote the opinion of any other Author on the subject, and surely, when we consider the nature of the gout poison, and that it is circulating throughout the system, we cannot be surprised if in some subjects it gives rise to insanity. Surely depositions of urate of soda in the brain are calculated to cause as much disturbance of that organ, as a deposit of the same matter in the stomach, or great toe would produce in the respective localities. Scrofula, again, is a disease essentially having a blood origin ; that is a taint exists in the blood, which is capable of being handed down from generation to generation, and under the application of depressing influences, we may, and frequently do, get in such subjects, morbid matter which had been previously deposited from the blood, called into activity : but although such morbid matter frequently gives rise to acute hydrocephalus, it is not so much with the deposition of tuberculous matter that we have here to do, as with that taint of the blood which existing, causes the organization to be *less perfect*, the tone of the

system generally *less vigorous*, and *more prone* to take on morbid action, and that, not only from the presence of that taint, or impurity, which must according to the degree in which it exists, tend under favorable circumstances to develope morbid action. Scrofula, then, ought not only to be a fertile source of the malady in question, but also of all those affections of the nervous system which are marked by morbid irritability; not that the nervous system, as I have endeavoured to show, is primarily affected, but because the taint in the blood prevents the formation of healthy tissue. It is well-known that a predisposition to hysteria will be brought about by anything that impairs the energy, or increases the excitability of the nervous system. Sedentary habits, living in an impure atmosphere, an atmosphere more especially deficient in ozone, and, in fact, anything that tends to bring about an anæmic condition, or exhaust the powers of life more rapidly than those powers can be renewed, will act in like manner. There can be no question that the different structures of the body have an elective influence over diseased conditions of the blood, there being a greater tendency to a deposition of some morbid matters in some structures than in others, and there cannot, I think, be a question but that the nervous system throughout, and the brain especially, is that portion of the human frame which is most liable to suffer from a taint of the blood, and for this reason, that the nervous system, taken as a whole, is that structure which regulates the deposition of matter from the blood, as, without its influence, tissue could not be formed, or at any rate endowed with vitality.

The formation of a living structure depends, not only upon certain elements of the blood being deposited on the surface of living structures, but each particular element has to be laid down in its right place, a work of election that is undoubtedly performed under the direct influence of the nervous system, and thus we cannot fail to perceive, that every part of the nervous system is able to appreciate the work it has to do, and this, not only with regard to the building up the body as a whole, but the removal also of effete matter. But the brain, as the seat of the mind of man, that organ in which the reasoning faculties exist in their highest state of perfection, must from that very fact be that part of the animal machine which is most capable of taking cognizance of an unhealthy state of the blood. In the brain of man, the mind is formed by vital force being given to it by the blood; the brain itself could not exist without the blood flowing to it to nourish it, neither could the brain appreciate a fact, or receive an idea, unless it had, as it were, stored up in itself a due amount of vital force, and when we regard the blood as a means of supplying this force, as we are obliged to do, we cannot be surprised that the mode in which healthy blood circulates through the capillaries of the brain, has so much to do with maintaining or interfering with a healthy state of the mind. How great then must be the influence of vitiated blood circulating through the same channel, how irritable and yet how weak, must be the powers of the mind, when the blood, from a low or disordered state of its own vitality, is incapable of imparting a healthy amount of vital force to the

brain. The question, however, may legitimately be put, how then do you account for those bright intellects which are not unfrequently found in those who are being rapidly consumed by some form of scrofulous disease? I would reply, simply, that morbid matter has, in such cases, been deposited in some portion of the brain or its membranes, and by its presence is giving rise to unnatural excitation, and to a brilliancy of intellect which is preternatural; precisely in the same way as a deposit of tuberculous matter in the membranes of the brain of children, will, as one of the earliest symptoms of the disease, render the child unnaturally precocious.

But we may have poisons circulating in the blood that are not connected with the diseases above named, indeed it would appear that almost every remedy absorbed into the blood has a direct action on the blood. Thus opium acts as a destroyer of the effects of belladonna; belladonna itself is considered a preventive of scarlatina, strychnia destroys the effects of prussic acid, and *vice versa*. Mercury has a great effect in destroying the vitality of the blood by breaking up the corpuscles. The absorption of lead produces paralysis very possibly much in the same way. The introduction of a small quantity of the vaccine virus into the system, causes the blood to undergo such a change, that the system is rendered, to a very great extent, incapable of taking an attack of small pox for some years afterwards. A single attack of scarlatina or measles will produce a certain amount of immunity from similar attacks, doubtless from the blood having acquired a different character from the disease it has

undergone. As it is of importance that the point of blood poisoning should be proved as distinctly as possible, I will just refer to scarlatina and diphtheria, two diseases in which it appears to me that such is particularly marked, referring those present to Mr. HARRINSON's paper for further information on the same subject. The most prominent symptoms of a simple attack of scarlatina are sore throat and rash. Now supposing the poison producing the disease to have entered the blood through the lungs, the throat is the part which would be most liable to an attack of inflammation, and subsequent ulceration, for this reason, that the poisonous germs would be deposited to a greater or less extent upon the mucous membrane of the fauces, where, by moisture and the process of absorption, they would be drawn into the textures of the part, and so would give rise to inflammation of a more or less severe character. But the poison having been conveyed into the lungs, and so drawn into the circulating fluid, (MR. LIONEL BEALE in his late lectures at Oxford, has given very valuable information on the mode in which this may be effected,) would naturally set up diseased action of the blood itself, and such diseased action would be attended with the development of more or less heat. But should the morbid matter absorbed be sufficiently powerful, it will produce death rapidly, by rendering the blood unfit to support the powers of life. If we contemplate the symptoms in these severe cases, we cannot fail to observe, that they all point most unmistakably to the same blood poisoning, and only differ in degree; thus, in severe cases, the pulse is

small, indistinct, and irregular from the first, there is a stupid heavy coma, or violent delirium with deafness, the ulcerations in the throat are deeper and more severe, and covered with dark instead of white sloughs, the tongue is lined with a black chappy crust, and is exquisitely tender, the breath is fœtid; the rash, extensive from the commencement, assumes a livid hue with intermixed patches of ghastly paleness, and death ensues about the seventh day. Now all the symptoms are undoubtedly direct evidences of the blood being in a state incapable of maintaining the powers of life. Diphtheria is too analagous to need further comment, indeed I feel I have already laid sufficient stress upon this matter, and will now pass on to the consideration of the brain and nervous system generally as an animal machine. UNZER, "On the Principles of Physiology" says, "all the phenomena of motion and sensation manifested through the nerves, render probable the existence of a remarkably subtle fluid essence, which is present invisibly in the medulla of the brain and nerves, and is the means whereby all the functions of both are performed. It is termed the vital spirits, or nervous fluid, but it is not known how, or when it contributes to the animal actions."

We have already seen the views of DRs. BUCKNILL and TUKE, with regard to the action of the blood upon the nervous system, and the mode in which force acts upon the nerve fibre. I must now trouble you with a quotation from the work of DR. FORBES WINSLOW, "On obscure Diseases of the Brain and Mind." He relates some interesting, and I think very instructive,

experiments of DR. DRAPER with reference to impressions made upon material substances, cognizable to sense, and says "do these throw any light upon the physical and psychical phenomena of memory? If on a cold polished piece of metal, any object, as a wafer, is laid, and the metal then be breathed upon, and when the moisture has had time to disappear, the wafer be thrown off, though now upon the polished surface, the most critical inspection can discover no trace of any form; if we breathe upon it, a spectral figure of the wafer comes into view, and this may be repeated again and again, nay even more, if the polished metal be carefully put aside, where nothing can deteriorate the surface, and be so kept for many months, even for a year, on breathing again upon it, the shadowy form emerges; or if a sheet of paper on which a key or other object is laid, be carried for a few moments into the sunshine, and then instantaneously viewed in the dark, the key being simultaneously removed, a fading spectre of the key on the paper will be seen, and if the paper be put away where nothing can disturb it, and so kept for many months, at the end thereof if it be carried into a dark place, and laid on a piece of hot metal, the spectre of the key will come forth. In the cases of bodies more highly phosphorescent than paper, the spectres of many different objects which may have been in succession laid originally thereupon, will, on warming, emerge in their proper order. These illustrations show how trivial are the physical impressions which may be thus registered and preserved. A shadow is said never to fall upon a wall, without leaving thereupon its permanent trace, a

trace which might be made visible by resorting to proper processes. But if on such inorganic surfaces, impressions may in this way be preserved, how much more likely is it that the same thing occurs in the purposely constituted ganglia. So much for the mechanical act of memory. DR. FORBES WINSLOW goes on to remark, that "comparing the aggregations of grey matter on the hemispherical surface of the brain, to a galvanic battery placed at the extremity of, or in connection with, a number of electric wires (the white or medullary cerebral matter), we can easily understand if any of these should become deranged, and not be in a healthy condition, or the battery (*i.e.*, the brain) out of order, that the ideas cannot be freely transmitted (in consequence of a breach of continuity in the channels of communication or efferent nerve tubes), in obedience to the mandate of volition, originating in the primary dynamical centre of the cineritious portion of the cerebral mass, or that the impressions made upon the feeble (disordered?) efforts of the mind, upon the motor or sensor powers may be faint, confused, or altogether unintelligible."

I am well aware that there are some gentlemen here, who know that I have been making some investigations on the blood, with a view of showing the precise nature of the force by which *all the processes of animal life are kept up*, and as the *nature of the force* has much bearing on the subject with which we are dealing, I trust you will pardon me for briefly running over the main points. They are simply as follows: that wherever healthy arterial blood circulates in the capillaries, there it has the property of giving out or

imparting to the textures, a force which is none other than the electric and magnetic (for I believe the two forces cannot be separated). Now this force is acquired in the lung, and the venous blood, as it comes to the pulmonary capillary charged with carbon, is in a state very similar to an unmagnetized steel bar (*i. e.* iron containing in its structure a considerable portion of carbon.) During expiration, certain waves of electric force are sent by the nerves round the capillaries, (and bear in mind, Gentlemen, that this does not rest upon simple hypothesis, for it is known that currents of electric force do circulate in the nerves during their state of action,) now these currents would have the effect of converting the steel bar, if it were present, into a permanent magnet, and do, as I believe, convert the blood corpuscles into magnetic bodies, by causing the oxygen of the air to enter them, and the carbon to pass from them into the air cells, from which it is expelled by the act of expiration. Now it is known that oxygen is one of the most powerful magnetic bodies known, acting the same part to the atmosphere, that iron does to the earth, but it is not simply oxygen that is absorbed in the lungs, and made subservient to the carrying on of the processes of life, but it is absolutely ozone, that is, oxygen in its allotropic state, the state of its greatest activity, its greatest density, and the state in which its electro-negative characteristics are most conspicuously shown. Now the effects of this absorption of ozone by the corpuscles of the blood, would be, not only to endow them with a force which would enable them to carry on the vital changes which take place in the system,

but also to give rise to certain mechanical changes in the shape of the corpuscles, which are very characteristic of the existence of the electric and magnetic force, but do not correspond with any other force known. Thus the spherical venous corpuscles become elongated in one direction, and shortened in the other, and the latter to such an extent as to render them biconcave, and these alterations in shape are particularly marked in blood that is said to be inflamed, and in which state there is a considerable increase of fibrine, and the existence of fibrine being dependent upon force, any increase of fibrine must be an indication of increase of force.

DRS. BUCKNILL and TUKE graphically call the blood a living organism, and it undoubtedly is the case that the corpuscles are cells in a more or less fluid state, a state in which they would be capable of having their shape altered by any force acting upon them from within. Now it will be remembered that the lines of force in the electric and magnetic states, are always at right angles to one another, and that there is elongation in the axis of electric force, and shortening in that of magnetic force, so that supposing a compressible globular cell was acted upon by these forces, there would be elongation in the electric axis, and shortening in the magnetic axis of force; a state precisely corresponding with that which we find in the arterial corpuscles, and which is carried to an abnormal extent in the corpuscles of inflammatory blood, where we have also, as I have before remarked, other indications of the existence of a greater amount of force. For the purpose of showing, Gentlemen, that I am

not singular in supposing that vital force is closely allied to mechanical force, I will give you another short quotation from a writer who is generally admitted to be one of the deepest thinkers, as he is undoubtedly one of the ablest physiologists of the present day, viz: Professor Owen. "It seems to me then, more consistent with the present phase of dynamical science, and the observed gradations of living things, to suppose that sarcode or the protogenel jelly speck should be formable through concurrence of conditions favouring such combinations of their elements, and involving a change of force, productive of their contractions and extensions, molecular attractions and repulsions, and that sarcode has so become, from the first period, when its irritative repetition resulted in the vast indefinite masses of eozoon, exemplifying the earliest processes of formification, or organic crystallization, than that all existing sarcodes or protogens are the results of genetic descent from a germ or cell, due to a primary act of miraculous interposition." It appears to me, and I think there are many who will concur in the opinion, that the power concerned in the formation of a germ cell of the present day, is no less miraculous, than that which caused the formation of the first. I, for one, believe that it is very possible to form cells *artificially*, *the germs of matter being given us*, nay more, I have seen cells form under the influence of a voltaic current, but I believe that there has been no cessation of the miraculous power since the formation of the first germ cell, for the existence of which, both matter and force were absolutely essential. But the earth and

different species of its inhabitants, once formed, the various species would propagate their offspring in a mode similar to that in which a chemist, with certain bases, can form compounds, the Creator acting as the chemist; and I speak, I hope, with all reverence, but in the living species, these compounds have to be endowed with life or motion, *i.e.*, a capability of acting and re-acting upon each other, until by an aggregation of particles, the living thing attains the limits destined for it to occupy as a terrestrial being, after which the process of decay begins to take place, and at length it sinks into the earth from which it was taken, to form material for supporting future generations. I am speaking, you will perceive, simply of that which constitutes a living thing, without reference to those higher qualities which pertain to the soul, those points on which it behoves us all to be perfectly clear, and our faith un mistakeable, but which do not in any other way pertain to the mode in which animal life is carried on.

To establish the movements of electric force in the nerves during their state of action, I must refer you to the experiments of DU BOIS RAYMOND, MATTEUCCI, ALDINI, and others; they establish the fact, and such being the case, it is quite certain that each pulsation of the heart, must send a corresponding wave of electric force through the ganglia of the sympathetic to the lungs. It follows that when these ganglia perform their part in the animal economy, they at one and the same moment act upon the blood in the capillaries, and cause expiration, by stimulating the muscular and contractile tissue. But whence the

source of the electric force in the heart? I must, for the purpose of establishing this point, ask you kindly to remember not only the arrangement of the muscular fibres of the heart, but also the mode in which the nerves are distributed therein: as they have been described by DR. ROBERT LEE, they all take a spiral course. DR. LEE says, "that large flat nerves pass to the root of the left coronary artery, which they not only surround completely like a sheath, but likewise cover a portion of the aorta near its origin. Ganglia are formed of considerable size on the superficial nerves, where they are crossing the blood vessels." A point of considerable importance, as I shall endeavour to make clear, by reference to DR. LIONEL BEALE'S recent investigations. "And it can clearly be demonstrated," says DR. R. LEE, "that every artery distributed throughout the walls of the uterus and heart, and every muscular fasciculus of those organs, is supplied with nerves upon which ganglia are formed, and which are the sources of all their contractile powers."

I must now call your attention to the lectures so recently delivered at Oxford by DR. LIONEL BEALE; and the part to which I especially refer, is that in which he speaks of ganglion cells with a straight and spiral fibre. The structure of the ganglion cells of the ganglia of the frog are remarkable. "In the year 1863, I presented a paper to the Royal Society, in which I showed that each cell possessed at least two fibres, and demonstrated the important fact, that these fibres pursued *opposite* directions in the nerve trunks to which they passed, one apparently going *towards*

an organ, while the other went *away from* it in an opposite direction. One of these fibres formed a beautiful spiral coil. In some cells there was but one spiral turn, but in others as many as eight or ten could be counted, while in some again, which were probably the oldest cells, the spiral turns were still more numerous. The spiral fibre comes from the outer part of the body of the cell, and the straight fibre from its central part, so that the tissue of the first is in structural continuity with that of the last; the body of the cell being composed of matter which may be said to be drawn off from one part to form the spiral, and in another to form the straight fibre." It will be sufficient to add, that DR. LIONEL BEALE, from sundry observations he has made, "has arrived at the conclusion that these cells are the *sources of nervous power*, and that the caudate nerve cells are more probably concerned in the distribution and radiation of the nerve currents." There are two modes in which these coils would act as intensifiers, if not absolutely as originators, of nerve force, provided that force is electrical. Thus if two wires of equal length be taken, and one made into a helix or coil, and the other laid out on the floor, and if each be used to connect the mercury cups of a small battery, a very great difference will be observed in the size of the spark afforded by each on breaking contact. Supposing the length of each to be sixty feet, the wire laid on the floor will give a small bright spark, while the wire wound into a helix will produce a brilliant spark, accompanied by a snap. Secondly, the arrangement of the nerve fibres of these ganglia corresponds precisely with the arrangement of

the wire, in a solenoid, that is, a wire so bent as to convey a rectilinear, as well as a sinuous current of electricity at the same time. In his description of the characteristics of these solenoids, DR. NOAD says, "two solenoids exhibit towards each other the phenomena of attraction and repulsion, in a manner precisely similar to two magnets, and a solenoid is influenced by a magnetic bar precisely as another magnet would be; in short, a solenoid has all the properties of a magnet, and when suspended and traversed by a strong electric current, it will range itself with its axis parallel to the axis of the declination needle."

Now it will be seen, that although a current of electricity of a known force, be sent by the efferent nerve into the ganglia, force would be increased by its passage through the coils of the ganglia, and during the passage of the current of force, the ganglia themselves *would become magnetic*, and thus the state of a living organ would be materially changed by such current of force sent to it, and a *secondary* force generated, and the tendency, moreover, of this secondary force would be, *to alter the axis of force in the nerve and the ganglia*; because the current in the coils of the ganglia would, if it were possible, place itself parallel to the current in the nerve fibre. *I do not say that this change in the axis of force is absolutely the sole cause of muscular contraction, but it does not appear unreasonable to suppose it would have very great influence in effecting such an end.*

DR. LIONEL BEALE asserts that the physical basis of every living thing is protoplasm, and this proto-

plasm, whether living or dead, solid or liquid, roast or boiled, is albumen or protein, derived by direct descent from the primeval protoplasm or bathibius, and composed of the four simple gases, to which its properties, as the physical basis of life, are due." This, no doubt, is perfectly correct, but even in inanimate nature, so called, a force is wanted to cause those gases to act and re-act on each other. The law of the diffusion of gases, will, it is true, cause them to mingle, but I would ask if that law itself is not due to the action of a mechanical force or forces? If so, must not the manifestation of force be much more essential for the production of any vital act? It is true that in a dead animal, there may be every essential for the carrying on of life, with the exception of the vital force; but when that force is imparted to the germ cells, then we have all the phenomena of life established.

I trust I shall be pardoned for importing into this paper that which, at first sight, may be considered as extraneous to the subject. It is not, however, really so, for it is by going into the minutiae of the matter, that we arrive at the great fact that a force is circulating in the nerves, which, according to the researches of DR. LIONEL BEALE, and some others, is increased by a peculiar arrangement of the fibres of the nervous system, and that arrangement accords with the principles of certain well known mechanical forces. Thus, I think, giving evidence that if the vital force is not absolutely identical with the electric and magnetic, the analogy between them is most strikingly marked. We know, moreover, that this force is de-

rived from the blood, and DR. L. BEALE, one of the most advanced of our microscopic physiologists, and one who has thought much upon what constitutes life, with regard to the ganglion cells of the heart, writes as follows: "The early development of these cells and their large size, at a time when the caudate nerve cells are not to be distinguished, their constant presence, their growth and multiplication in the adult, and probably at an advanced age, and their peculiar structure (at least in some animals), their situation as regards the nerves to which they belong, and especially the fact, that these are only cells constituting the nerve centres upon which the rythmic contraction of detached portions of the cardiac muscular tissue depends, have led me to look upon these cells as the *sources of nervous power*." Now if the action of the heart depends on a magnetic column of blood in its interior, and the circulation of blood through the textures of its walls, combined with currents of electric force in the nerves, (in fact, constituting the heart as a magneto-electric machine,) then these cells, existing in detached portions of the organ, would retain this force, and keep up rythmical action until the magnetic force had become exhausted, in a manner similar to the gradual loss of force in an ordinary magnet.

Under such circumstances, we cannot do less than admit, that anything which interferes with a healthy state of the blood, must interfere with the vital force dispensed by the blood to the tissues, and correspondingly alter the character of the impressions made upon the larger nervous centres, and brain especially,

and we can be at no loss to understand, that the structure of the brain itself may be so altered by a persistent circulation of unhealthy blood through its meshes, that the ideas or mental impressions may give evidences of disease, and yet that no microscope may be able to detect the morbid tissue, and upon this point I think the experiments of DR. DRAPER, to which I have referred, are most instructive.

The practical utility of knowing of what this vital force consists, is really of equal importance to the study of medicine as a science, as is the knowledge of what is health, before attempting to define a disease, for so long as we know little or nothing of the nature of the force that works the animal machine, we can know but little of the mode by which we can add to that force when it is deficient, or abstract from it when it is in excess; for instance, if we know the electric and magnetic relations of bodies to one another, we can tell precisely the affinity which they exert for one another; and if we discover that a certain virus exists in the blood, changing its physical character, the science of medicine would direct us to ascertain the antagonistic principle which must be introduced to counteract the effects. We all acknowledge the great advance medicine made as a science, owing to the discovery of the circulation of the blood, and surely the practical utility of that discovery would be very materially enhanced, could we but arrive at the nature of that force, which, existing in the blood, renders it capable of fulfilling the great work for which it was ordained.

and we can be at no loss to understand that the structure of the brain itself may be so altered by a persistent circulation of unwholesome blood through its vessels, that the ideas or mental impressions may give evidence of disease, and yet that no microscope may be able to detect the morbid tissue, and upon this point I think the experiments of Dr. Brouard to which I have referred are most instructive.

The practical utility of knowing of what this morbid condition is really of equal importance to the study of medicine as a science, as is the knowledge of what is healthy before attempting to determine given a case how far we know little or nothing of the nature of the case that works the natural meaning we can know but little of the mode by which we can

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it is in a case of disease, if we know the nature and properties of the blood, we can tell precisely the effects which they exert for one another; and it is likewise certain that some action in the blood, changing its physical character, the action of medicine would direct us to correct the morbid principle which must be introduced to counteract the effect. We all know that the great advance made in medicine, owing to the discovery of the circulation of the blood, was surely the practical utility of that discovery, and it is very manifestly evident that we have arrived at the nature of that force, which existing in the blood renders it capable of fulfilling the great work for which it was ordained.

With the Author's Consent



ADDRESS
DELIVERED AT THE
ANNUAL MEETING
OF THE
READING
Pathological Society,

On SEPTEMBER 11th, 1889.

BY

R. C. SHETTLE, M.D.,

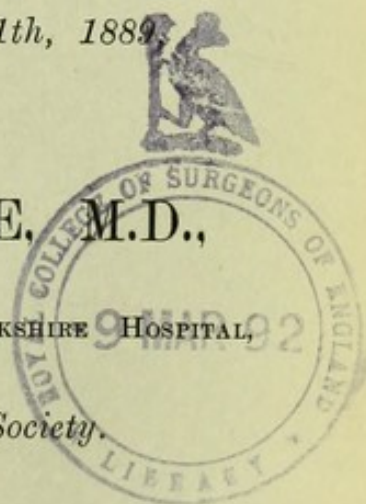
SENIOR PHYSICIAN ROYAL BERKSHIRE HOSPITAL,

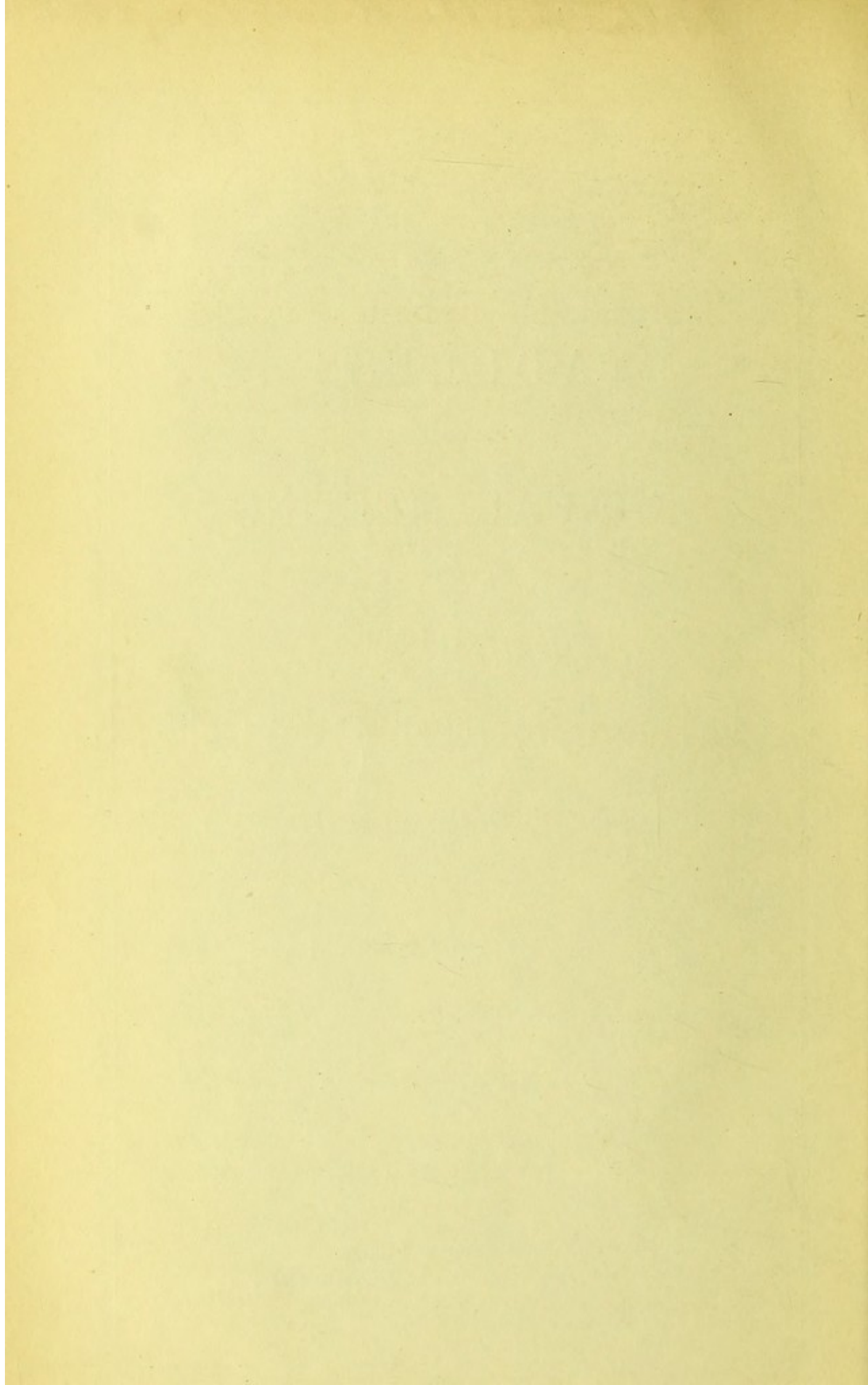
President of the Society.

Reading:

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Reading Pathological Society.

ADDRESS

DELIVERED AT THE ANNUAL MEETING

By R. C. SHETTLE, M.D.,

President of the Society.

GENTLEMEN,

The day has arrived when as the President of this Association I am called upon to deliver an Address, and I believe, strictly speaking, it ought to be retrospective, and to fulfil that duty I, as far as possible, have transcribed an account of the work that has been done at our monthly Meetings, and am prepared to go over that ground again if it be the wish of this Meeting. The cases brought forward and the work done have been quite on a par with those of other Sessions of our Society, but there appears to me no good and sufficient cause why some special topic should not form the subject of the Annual Address; in the first place, because, otherwise, the points brought forward must be more or less fresh in the recollection of all; and in the second, because it is evidently impossible that the salient points of those cases can be shown, threshed out, and have new light thrown upon them in the brief period allotted to the Annual Address. Again, I am disposed to think that an Address framed upon other lines may come with more

freshness and thus merit your approval. I have therefore selected a subject suggested by one paper in the list of subjects discussed at our monthly Meetings, viz: the paper by Mr. MAY; and without entering upon the consideration of Bacteriology in particular I have endeavoured to make good the remark which I then made in connection with Mr. MAY's treatment of his subject, viz: that Pathology in general was based upon a knowledge of the mode in which these, or other organic germs, modified vital action.

It is for you, Gentlemen, to decide which line I shall take.

The title of my paper is "The Physical nature of the vital force, the *mode* in which the blood converts Potential into Kinetic energy, and establishes nerve currents, which correspond with and are in proportion to the kind and degree of the blood currents, together with the power which unsuitable, or foreign, matter possesses to originate disorder and disease."

With your kind permission I will now offer some remarks upon these Physiological and Pathological subjects, and shall endeavour to make it clear that all diseases, however varied in their character, are the direct outcome of some material dyscrasia, *i.e.*, some departure from the material condition which is essential to the production of the common phenomena recognised as natural to an organ, a tissue, or a cell.

A discussion as to the exact nature of this dyscrasia must necessarily be highly interesting to all engaged in the practice of medicine; inasmuch as it should tend to remove, and will, as I believe, eventually remove all mystery as to the cause, nature, and treatment of disease.

I must however premise that in support of the views to be advanced I shall quote freely from authors who have carefully investigated these subjects.

My subject may be regarded under two principal heads.
(i) The material or physical condition of the human body in the forms and conditions of the matter composing it, and
(ii) the nature of the force which, with those forms and conditions of matter, causes the evolution of vital phenomena.

I must at the outset, refer to LANDOIS and STIRLING'S admirable text book of Human Physiology.

Before proceeding to deal with strictly physiological subjects the author refers to matter and the forces acting upon it; a knowledge of which is as essential to the physiologist as is a knowledge of the nature of his materials to the mechanic about to construct a machine. For it is obvious that in such work if a wooden plug was substituted for an iron or brass screw, the construction when tried would be useless. So it is with regard to the living body; for the non-recognition of the nature of the different forms and conditions of matter, and that each has a special work to perform, makes all a mystery, and not infrequently leads the physician to believe that he can do little or nothing, because he knows so little about the great origin of disease.

My quotations shall be as brief as possible consistent with the end in view.

Of *Matter* LANDOIS writes thus, "The entire visible world including all organisms consists of matter, *i.e.*, of substance which occupies space. We distinguish between ponderable and imponderable matter, the latter generally termed ether.

"The ether penetrates into all the spaces between the ponderable particles, which can never come so close as not to leave interspaces. All matter must, therefore, be regarded as more or less loose and open in texture, although the ponderable atoms are arranged in a definite relation to the ether atoms.

"This relative arrangement of the molecules of matter determines the aggregate condition of the body."

Of *Forces* he says, "All phenomena appertain to matter, and these phenomena are the appreciable expression of the forces inherent in matter. Every form of matter possesses potential energy, or energy of position, and this potential is converted into kinetic energy by motion."

Of *Heat* in relation to potential and kinetic energy he expresses himself thus; "If a weight be thrown down and it

strikes an unyielding substance the movement is arrested. And the kinetic energy which appears to have been lost is transformed into a lively vibratory movement of the atoms called *heat*. All the atoms vibrate like a pendulum and their movement being communicated to the ethereal atoms is then 'radiated.' The amount of heat is in proportion to the amount of kinetic energy which is transformed through the concussion. Hence heat is a vibratory movement of atoms."

Of *Chemical Affinity in relation to heat* his words are, "Whilst gravity acts upon particles of matter without reference to the composition of the body, *chemical affinity* is a force by which the atoms of chemically different bodies unite to form a chemical compound. Chemical affinity may be strong or weak, and we can estimate the strength by the amount of heat yielded when the bodies combine."

As to *Conservation of Energy* JULIUS ROBERT MAYER and HELMHOLTZ established the law that in a system which does not receive any influence or impression from without, the sum of all the forces acting within it is always the same. "The various forms of energy can be transformed one into the other, so that kinetic energy may be transformed into potential energy and *vice versâ*, but there is never any part of the energy lost. The transformation takes place in such measure that from a certain definite amount of one form of energy, a definite amount of another can be obtained."

The various forms of energy acting in organisms occur in the following modifications:—

(i) *Molar* motion.—Ordinary movements as of the whole body, of the limbs, of the intestines, and even those observed microscopically in connection with cells.

(ii) Movements of atoms.—In connection with the vibrations of atoms, the number of vibrations in the unit of time determines whether the oscillations appear as heat, light, or chemically active vibrations. Heat vibrations have the smallest number. Light vibrations stand between the two. In the human body we observe only heat vibrations.

(iii) *Potential energy*.—The organism contains many chemical compounds characterised by great complexity of constitution.

(iv) The Phenomena of electricity, magnetism, and diamagnetism may be recognised in two ways, (i) as movements of the smallest particles seen in the glowing of a thin wire when traversed by strong electrical currents (against considerable resistance), and (ii) as molar movements, as in the attraction and repulsion of the magnetic needle.

It is not improbable that the electrical phenomena manifested by muscle, nerve, and glands become almost completely transformed into heat.

"It is quite certain that within the organism one form of energy can be transformed into another form, and that a certain amount of one form will yield a definite amount of another form; further that new energy never arises spontaneously, nor is energy already present ever destroyed, so that in the organism the law of the conservation of energy is continually in action."

Of *Animals and Plants* LANDOIS states, "The animal body contains a quantity of chemically-potential energy stored up in its constituents. A continual process of combustion takes place by which simpler substances are formed from the more complex compounds, whereby potential is converted into kinetic energy," due to the vibrations of the corporeal atoms.

Of *Vital energy* he states, "The vital forces which act in organisms in plants and animals are exactly the same as are recognisable as acting in dead matter. A so-called 'vital force' as a special force of a peculiar kind, causing and governing the vital phenomena of living beings, does not exist."

In these quotations or summaries I have perhaps sufficiently referred to preliminary facts, bearing upon the question of the physical or non-physical nature of the force producing and sustaining the phenomena of animal life, to show—

(i) That the total amount of potential energy in the material structure of an inanimate body may be and often is converted into kinetic energy.

(ii) That when it has been so transformed it is just that amount of energy which is required for the proper maintenance of the vital functions of the organism.

(iii) This is evident because the potential energy of any form of matter is in proportion to its gravity; in other words to its density or weight.

(iv) As density varies with the nature of the matter and its temperature, so upon the same principle must the vital phenomena of an organism vary.

This is readily understood if we consider the different degrees of mechanical force required to move or affect the particles of a gas and those of a solid mass (as of lead) occupying the same space. Similarly, the resistance which any tissue or form of matter offers to the transmission of energy varies with the physical character of the matter.

The importance of this fact in its bearing upon Pathology cannot be over-estimated. This will appear in the sequel.

And now leaving the consideration of *all* matter *generally*, may we not assume that in the organic world the blood or other nutrient fluid in animals, or the sap in vegetable life, is the material agency by which the conversion of potential into kinetic energy is maintained? Still further, and with more limit, confining attention to the animal kingdom, I feel that an apology is due to my audience when I state that the phenomena of life, when integrity of structure exists, are clearly in direct proportion to the circulation of healthy arterial blood.

But there are at least two facts of very great significance involved in this circulation of the blood, and of these physiologists generally have as yet taken but little notice. I mean (i) the physical characters of the blood corpuscles, and (ii) the mode in which they acquire the power to disturb and create currents of energy in adjacent nerves even without direct contact.

This absence of contact cannot however prevent them from exerting a distinctly physical force, producing induced currents of energy in precisely the same way as a bar of

soft iron, without touching a magnet, may be made magnetic by mere proximity.

But how, let me ask, does the blood accomplish this important work? And are there any physical laws which ensure the work being done?

I reply that there are, and further that it is a marvellous thing that they should not have been recognised until this 19th century, seeing that in so many fields of research there have been such great additions to our knowledge.

A very few minutes will suffice to enable me to define my meaning and to render the matter quite clear to every one at all acquainted with the laws of magnetism and magneto-electricity. By stating certain facts I shall show that, at any rate in the case under consideration, force does not act at a distance.

I take a number of magnets and suspend them at such distances that they cannot touch each other. I allow them to take up a definite position and come to rest, but you will admit that I cannot move one of them without effecting a change in the position of all the others. This general change of position is effected by the well-known magnetic force proceeding in regular and beautiful curves in every direction from the poles of a magnet, so that every magnet is surrounded with a spheroidal-formed atmosphere of its own force. Again, every known form of matter when it is free to move and is brought into this magnetic field takes up a definite position, a position determined by the mode in which the matter of which it is composed deals with, or transmits the force acting along these natural lines. These are two very important well-known facts and the principles giving rise to them regulate, as I shall show, not only all the processes of natural formation in the living body, but when matter is introduced into the living body which ought to be foreign to that body, give rise to *all those processes of change which constitute morbid action*.

Now I must take you a step further and draw attention to the fact that the earth is a magnet, one indeed of a series of magnets such as I have supposed, consequently every form

of matter on its surface, or in its crust, is permeated by these same lines of force which extend for a long distance as a magnetic atmosphere into what may be called space. Thus the animal body as one of these small collections of matter is traversed by force and these same lines of force, and as all the processes of growth and nutrition are effected, whilst the elementary particles aiding growth and nutrition are free to move from their being held in solution, they are polarised by these same lines of force traversing the most intimate structure of each. These particles are deposited where they are required under the influence of the same force which regulates the formation of crystals, and will separate, in the mother liquor, one form of matter from another.

I now come more particularly to the circulation of the blood, and to the mode in which it disturbs the potential energy of the matter, of which the body is composed, and converts it into that kinetic energy which traverses the nerves and other tissues, and is then recognised as vital energy.

Here we have to consider the relations which exist between the blood and the tissues, more particularly with reference to the magnetism which permeates the dead as well as the living body.

We must first recognise that the blood is composed of—or may, for the purposes now under consideration, be roughly divided into—two very distinct portions, viz: the corpuscular portion and the plasma.

It is now some years since Dr. ARTHUR GAMGEE proved that these two portions differ widely in their physical properties as regards magnetism, and that the corpuscles in both the venous and arterial states are highly magnetic, but suspended in a highly diamagnetic medium.

Long before the publication of these experiments by Dr. A. GAMGEE I had been working on this subject, and it was evident that if the corpuscles of the blood acted as disturbers of energy by reason of their magnetic properties, there must be differences between these physical properties causing such different magnetic conditions or effects.

I therefore set to work to test the point, and at last succeeded in establishing the fact that the arterial corpuscles are more magnetic than the same corpuscles when they exist in the venous state.*

We are now in a position to estimate the full significance of the fact when considered in relation to the powers which the arterial blood corpuscles exert as disturbers of potential energy :—for

(i) We recognise that the whole body is permeated, and that its particles are necessarily polarised by lines of magnetic force, which it contains in virtue of its being associated with the mass of the earth ;

(ii) That when the blood circulates, the corpuscles cut through and give a new direction to the lines of magnetic force, converting the potential energy of nutrient pabulum into kinetic energy.

We may here consider the intimate relations which subsist between the material substance and this force, producing *crystalline* forms.

It is well known and admitted that very many substances assume, under favourable conditions, a distinct geometrical form, based upon a certain regularity of *internal* structure, *i.e.*, upon the mode in which the particles are arranged when the crystal is being built up. So, *magnetically* and *electrically* regarded, it may be asserted as a fact that no two substances, or forms of matter, have similar magnetic or electric conditions, or resistances.

But perhaps the most delicate of all tests of the dissimilarity of the different forms of matter is spectrum analysis.

It has been proved that all the phenomena of light and colour are due to the mode in which matter, in any one of its forms or conditions, interferes with the vibrations producing light. Each known form of matter modifies the spectrum, and in so doing testifies to the distinctive polar characters of the matter.

* *Vide* Paper in the Proceedings of the Royal Society, 1875.

The important bearing of this specific dissimilarity cannot be too strongly insisted upon, when we are searching for the *cause* of the formation of healthy structures, and at the same time endeavouring to find out in what respects morbid structures differ, for this same law or principle holds good of organic as well as inorganic forms of matter; indeed, Sir G. G. STOKES has shown the differences which arterial and venous blood exhibit under spectrum analysis; proving that the two forms of blood deal with the vibrations of this physical force in a very distinctive manner.

I pass at once to a consideration of the force as it exists in the circulating blood, and the power which the blood column possesses of originating currents of energy in the adjacent tissues.

I have already stated that the corpuscles of the blood are highly magnetic in both the venous and arterial states; and also that the intensity of the force is greater in the arterial condition.

This fact, it appears to me, has a double significance—(i) in relation to the value which the positive, or arterial force, possesses of originating currents of energy; for magnetic force is always proportional to magnetic intensity,—and (ii) in the insufficiency of the venous corpuscles to arouse dormant energy.

The polarising influence of venous blood is not sufficient to set up molecular motion of the material particles; to effect this, additional magnetic force is required, and this is supplied by the absorbed oxygen.

I may state that oxygen is a magnetic substance, and as regards magnetism holds the same relation to the atmosphere that iron does to the earth; and further, the magnetic intensity increases with the density of the gas; the force being the greatest in the state of ozone.

We thus perceive something of the perfection of the mechanism by which animal life is sustained; for it provides:

- (i) That a constant supply of power shall be maintained; but
- (ii) That to render this effective, additional force and from without shall be supplied.

I have now shown (i) that every form of matter is permeated by the magnetic force of the earth; (ii) that the capacity for the force varies with the character of the matter; and (iii) that the power which any form of matter possesses to convert potential into kinetic energy is in proportion (*a*) to the intensity of its magnetic force; (*b*) to the rate of the motion; and (*c*) to the proximity of the matter to the moving blood.

It consequently follows as an axiom, that the amount of current energy in any living tissue of the human body must be in proportion—

- (i) To the quantity and character of the arterial blood,
- (ii) To the rate of its motion, and
- (iii) To its proximity to the moving blood column.

We can now fully realise the importance of the artery and nerve being placed as close to each other as possible—in many cases we find they are in the same sheath—and further the obscurity, not to say mystery, as to the mode in which natural or morbid vital processes are effected, is removed.

We recognise (i) that all natural growth of tissue occurs whilst the tissues formed and forming are alike subjected to a polarising force, practically constant in degree; and that this same force as in the act of crystallisation separates the particles of salts with the greatest accuracy; (ii) that in a state of health the nutrition and growth of the living body is carried on under the influence of a force which maintains a balance between nutrition and waste.

To render this clear I again refer to the act of crystallisation. In this process the direction of the force emanating from the formed crystal is the same as that which passes through the particles suspended in the mother liquor; and the attraction between these particles and the ultimately formed crystal is dependent upon the constancy of the force operating. Upon exactly the same principle the processes of nutrition and growth are maintained in the living body. The force is constant, and the matter supplied should be suitable. But morbid changes of every kind may be set up by reducing the

force, or by alterations in the character of the pabulum. For it is obvious that if the force is diminished then the formed matter cannot partake of those well-defined characters which are the essentials of healthy structures.

Again, if the matter supplied be excessive, or its character unsuitable, then deposits (interstitial) must be originated, and the structures proportionately changed.

The blood corpuscles, and especially the red, act as inherent possessors of force, in common with all matter, as carriers of force derived from the earth, and as disturbers of force existing in their surroundings.

I would here seek to explain the bearing of all this in a pathological point of view.

If the relative number of red corpuscles be lessened—as in an anæmic condition of the blood—we find certain results, some manifesting themselves in motion, as in the quickened pulse with palpitation and heightened respiration; others in organic enlargement, as of thyroid gland and spleen; others of a more general character, as lessened temperature, marked nervous irritability, depression, and in every way loss of tone.

How do the usual remedies—stimulating air, stimulating food, stimulating medicines, act? These tell mainly on the red corpuscles, which enlarge (for in anæmia they *shrink* as well as diminish in number); they resume their normal shape, whereas in the anæmic state they are somewhat oval or irregular in form; and thus as a general result, we find the natural amount of hæmo-globin and hæmatin reproduced. With this increase comes more oxygen, not only as that which forms an essential element in the composition of hæmo-globin, but also of free oxygen easily given off. If to this we add the increased power of absorbing oxygen which the greater amount of hæmo-globin necessarily affords, we can understand—duly remembering the specially magnetic character of oxygen—the loss sustained when blood is poor in red corpuscles, and what a part they play in the vital economy.

Then as to the tissues, what changes follow from anæmia? The muscular tissue of the heart shows a species of incipient

fatty degeneration; so do the epithelium and uriniferous tubules of the kidney; the hepatic cells of the liver are more than usually charged with fat, and the intima of the aorta loses its normal character. These changes may be referred to imperfect oxidation, but that is not satisfactorily determined, and even then it means defective power in the blood. Thus we have muscular weakness of the heart, with general weakness of bodily and mental functions. Emaciation may be an attendant result, or only an attendant symptom.

Passing from anæmia to leukæmia, what does the marked excess of white corpuscles, coupled with the markedly less dense red corpuscles, bring in its train?

The lymphatics are not at first enlarged. Would not this be the case if they caused the leukæmia? And, indeed, the lymphatic organs with the spleen also may become enlarged without any leukæmia. The comparatively few red corpuscles in this disease are softer than is natural in health, cohere more, but not as is usual in rouleaux—a fact that indicates great change and diminution in magnetic intensity. Their softness or diminution of density also proves the same, and as a result we have less coagulating power in the blood.

In the medulla of bone fat cells are superseded by lymphatic matter, whilst in liver and kidney, occasionally even in lung and muscle there is hyperplasia of cells in interstitial tissue, not to be explained by mere wandering of leucocytes. PAYNE on this point says, "There can be little doubt but that these formations of tissue are to be considered secondary, and a consequence of the condition of the blood." If the red corpuscles are few the magnetic force given out is less, tissue becomes disorganised, or rather *lacks the power to become organised*, and all the marked symptoms of want of *vitality* in the blood follow.

I cannot possibly enter upon a consideration of the morbid influences which microbes exert, farther than in the most general way to remark that these organised germs have a great variety of form, shape and motion; and that in proportion as they establish their own motion, they interfere with the natural currents of energy, and give rise to disorder and disease.

When it is perceived that the laws of magnetism hold good as much within as without the body, the full importance of the magnetic states of venous and arterial blood is recognised, and we cannot fail to see that currents of energy are induced by the motion of the blood in the nerves, muscles, and other tissues, or that the general activity of the vital processes must be in proportion to the same.

If we now look to the effects of cold applied to the surface of the body, we get a proportionate loss of power, defective oxidation of the blood, congestion of internal organs, more matter is sent to them than the vessels can properly transmit, especially under loss of power from defective oxidation, tendency to blood stasis commences, increases and becomes more or less complete, and in proportion exudation occurs; upon this we get magnetic force radiated by the corpuscles, just as in ordinary coagulation of the blood, under which the particles tend to cohere and solidify.

Functional disorders of the nervous system may, upon the same principle, lead to disease.

It may be said that the mode in which the currents are originated in the nerves and other tissues has no practical value, that we know they exist and that is sufficient.

A somewhat similar remark might have been urged with as much force with regard to the circulation of the blood. The blood was known to be moving in and through the body, and I suppose it was believed that in some way or other it nourished the body; but I venture to think there are now few, if any, who would not admit that our knowledge has been marvellously enhanced by HARVEY's great discovery.

I consider that no false delicacy should debar me from stating my full conviction that a recognition of the facts, principles and arguments which I have now had the honour of bringing before this Society, will have a most important bearing in the future; not only upon the practice of medicine, but also upon the means that will be adopted for the conservation of the public health.