tabetic subject as it, unfortunately, often does in the non-tabetic. We have seen hemiplegia not a few times in patients already the subject of tabes, but the case of B., and that of another patient, are the only cases in which the knee-jerk was present after that paralysis. (In the other case it cannot be asserted, as it can in the case of B., that the knee-jerk was absent before the onset of the hemiplegia. All that can be said is that it was present on the hemiplegic side after the attack.) Hence it would not be wise to draw any decided inferences from the case of B. In a valuable and interesting thesis,[1] Mademoiselle Edwards has collected a large number of cases in which hemiplegia occurred in the course of various other nervous disorders. Amongst them are several cases of tabes with this complication, but in only one case[2] are the knee-jerks noted as being present. It is not stated whether the knees had been tested before the onset of the hemiplegia.

Presumably in the case of B., the return of the knee-jerks was contemporaneous with the establishment of sclerosis of fibres of the pyramidal tract, in the bundle of deep fibres of the lateral column. It is well known that in many cases of uncomplicated hemiplegia, there is exaggeration of both knee-jerks. It has been shown by Pitrès, Schäfer, Sherrington, Hadden, Tooth, France and others, that at least in some cases of lesion of one internal capsule there follows degeneration of fibres in both lateral columns. If, in the case of B., there has been since January, 1890, double lateral sclerosis, his case anatomically is one of the "ataxic paraplegia" of Gowers.

Before the hemiplegia, or before the lateral sclerosis was well established, it may be that from the sclerosis of the posterior columns there were too few fibres left intact in those columns for strong enough or sufficiently numerous impulses to act on the anterior horns concerned, so as to produce the jerk. Upon the ensuing of lateral sclerosis, according to current doctrine, the anterior horns become more excitable. Thus it may be that after this change in the horns, the few fibres left intact in the posterior columns were sufficient for action on the horns so that the jerk could be elicited. If this be so, and if the posterior sclerosis increases, the presumption is that the jerks will be once more lost. It is not likely that the lateral sclerosis will increase, at any rate so far as the lesion causing the hemiplegia is concerned with it.

PRESIDENTIAL ADDRESS
ON
THE ENERGY OF THE ANIMAL BODY.

By W. F. CLEVELAND, M.D.,
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THERE seems to be in thoughtful minds a growing recognition of the fact that medicine and therapeutics are but in other words applied physiology; and I take it that applied physiology means, broadly, the effort to direct and influence those chemical changes which are continually taking place in the tissues of the body, known under the term "metabolism." Metabolism is defined as a process which goes on in every part of the body by which energy is stored up as well as set free. There are two kinds of metabolism: First, that which refers to the building up of the living substance, and is called "anabolism;" secondly, that which refers to the breaking down of the living substance, and is called "katabolism."

Now, if it be admitted that disease is a deviation from a healthy metabolism, it is but reasonable to conclude that the closer we are acquainted with the working of our organs in a natural state, the better able shall we be to restore harmony when they are out of tune. It is under this impression that I venture to lay before you some remarks on the subject, or I should say a portion of the subject, of the energy of the animal body or how work is done in the animal economy. But it may not be out of place to say a few preliminary words about energy in general, and especially about that great and inexhaustible source of energy—the sun.

Although the sun may not initiate life, still it is the principal source through which life is maintained—directly in the plant and indirectly in the animal kingdom. Were it not for the energy of the sun, the carbon and hydrogen, or raw material which goes to make plant life, might continue their inorganic and barren existence in union with oxygen for ever. But there is a peculiar body in plants, called "chlorophyll" or green stuff, and although this is an exceedingly unstable body, and has perhaps never been successfully isolated, there can be no doubt, as Dr. Halliburton says, "it is always present in vegetable cells, in which the formation of organic matter from carbonic acid and water, with elimination of oxygen, is going on." What the exact function of chlorophyll may be is at present a moot question, but it may be confidently stated that, through the energetic action of the solar rays on the carbonic acid and water surrounding it, carbon is separated from carbonic acid and hydrogen from water, and fixed or stored up in the plant as a hydro-carbon. This may be called the first production of vital capital, as far as we are concerned, inasmuch as this green stuff, through being built up, for instance, into grass, furnishes food for sheep, and sheep, in the form of mutton, furnish food or transmit the capital to man.

Animal life is permanently supported by what are called protein compounds, but these are only generated by plants, and plants can only generate them through the direct energy of the sun.

Now the green stuff of plants consists of carbon, hydrogen, and nitrogen. This last named constituent, nitrogen, is a very important one, for although it forms such a large portion of the atmosphere, and is physically diffused through the bodies of plants and animals, still as free or uncombined nitrogen, it is inert and of no chemical use. But mark the difference when it enters into the composition of the protoplasm of a vegetable cell, or the proteid framework of muscle. Nitrogen then is the pivot on which their metabolism turns, and nitrogenous bodies appear more or less as the products of all metabolism.

In the animal these products are cast out, but in the plant they are stored up, and may be often recognised as vegetable alkaloids, bearing a resemblance, if not closer relationship, to the nitrogenous product of animal metabolism, namely, urea. One word about the indestructibility of the sun's energy. In a potential form it may be locked up for centuries in the wood of the tree; but when the wood is burned the carbon and hydrogen are separated from each other, and again unite, respectively, with oxygen. Energy is set free which may be utilised, as you are aware, in ordinary machinery. Carbonic acid and water are formed, which may be again acted on by the sun and green stuff of the plant. But the potential energy of the sun's rays is likewise stored up in fruits, or food stuffs, and these undergo in the animal economy a process of slow combustion, in which an analogous chemical effect is produced, as when the wood of the tree is burned.

The word energy does not admit of a ready and off-hand definition. It seems to be that which is known by its effect. But, for the sake of convenience, we may say it is the inherent power, or force which, under certain conditions, effects a given work or labour. Energy is of two kinds; actual or active, and potential or latent. It may be familiarly illustrated as follows: The gunpowder in a loaded gun may be viewed as work-stuff, that is, something capable of yielding work, or, in other words something holding within itself energy, and here the energy is termed potential. Now when the gun is fired a great chemical change takes place in the gunpowder, and the energy or power, which was previously dormant and inert in it, is suddenly set free, or becomes actual, and is then called actual energy, because it actually does the work intended, or propels the bullet.

Now, every living child that is born into the world is born possessed of a certain capital, which may called its physiological patrimony. This capital is stored up in its body in the form of potential energy. And no sooner is the child born, than it must of necessity begin to spend this capital. It is through the potential energy, which may vary in amount according to the health and vigour of the parents that have supplied it, that the child is enabled to begin the great work of life, namely, to breathe. And this is a work, or

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[1] *Thèse de Paris.*

[2] *Obs.* ix, p. 35.

labour, that must be continued till the day of its death, so that, as Professor Huxley has observed, "it is no mere metaphor to say that man is destined to a life of toil; the work of respiration, which began with his first breath, ends only with his last. Nor does one born in the purple get off with a lighter task than the child who first sees light under a hedge."

But where is this potential energy located, and how is it set free or made available? In the complex mechanisms of our bodies the nervous and muscular systems fill an important place, and it is in the muscular tissue for the most part, or in the work-stuff or muscle-dynamite as it has been called (the something that is analogous to the gunpowder in the gun), that potential energy has been stored up. Under the circumstances of the child entering upon a new mode of life, such as is involved in respiration, the work-stuff is made to explode, or, so to speak, the gun is fired off, and the potential energy becomes actual, or sets in motion the respiratory muscles, and thus enables the child to breathe.

Now as respiration alone implies work that must be continually performed, and as the performance of that work implies the continual expenditure of energy, it is obvious that the capital of potential energy with which the child starts in life must be soon used up, and the machine come to a standstill just as the action of a steam engine would cease if it were not from time to time supplied with fresh coal and water. But Nature, equal to her task, has contrived a plan by which the child may, through a further slight expenditure of its potential energy—namely, by sucking—enter upon a profitable labour of taking into its organism materials, in the form of milk, physically and chemically suited for conversion into that work-stuff which, we have seen, is so indispensable to its existence. The labour is profitable because the food-stuff of the milk more than compensates for the energy expended in obtaining it, and the surplus is appropriated in adding to the child's original energy and developing its framework.

But not only are there constant and irrepressible calls upon the exchequer of energy for breathing, feeding, circulation of the blood, and other functions of the economy, but soon there come active voluntary muscular movements, so that, in a healthy state of the body, the adjustment of supply of energy to the demand must be a matter of no mean importance. But this is greatly augmented under temporary or permanent derangement of those organs, whose duty it is to prepare and elaborate the food, and present it in the form of nutritious blood to the nervous and muscular systems, those master tissues of the body, in order that they may build it up into their own substance. They are justly called master tissues, for muscular movement under nervous government or direction may be said to embody the principal function of life, and we may also be said to possess double nervous and muscular systems - namely, an external—by which we are known to the world while "we strut and fret our hour upon the stage;" and an internal, by which the movements of the machines or internal organs, which conduce to the necessary changes in the blood, are carried out.

Herbert Spencer has defined life as the continuous adjustment of internal relations to external relations. For the equivalent of this expression might I say that life is carried on by the continuous expenditure and renewal of energy; and as it is essential, in order that a lamp may burn with a steady light, that the supply of oil to the wick, and the exposure of the flame to the atmosphere, should be regulated with precision; so, in order to enjoy an equable flow of health, the supply, in quantity and quality of the blood, must be adequate to the replenishment of energy and renewal of substance, rendered necessary by the continual labour, voluntary and involuntary, which it is our lot to perform.

Before a learned and critical audience like this, it is not my intention to attempt more than a very brief outline of what are believed to be, at the present day, some of the facts connected with the nervous and muscular systems, premising, at the outset, that our knowledge continually fails to explain the "how" in reference to what takes place. Thus a muscle, in contracting, is altered in form but not in bulk, and it is supposed that a translocation of its molecules takes place, but as to the manner in which such translocation is effected we are in ignorance; nor is the use of the striation of muscle understood. But in whatever way translocation takes place it is believed to be the outcome of a chemical change, of an explosive decomposition of certain parts of the muscle resulting in the production of carbonic acid, in the increased acid reaction of the muscle, in the evolution of heat, and the setting free of muscular energy or the doing of mechanical work.

We should have naturally thought that during the contraction of a muscle, which, it must be remembered, is largely composed of proteid material, great nitrogenous waste would ensue, but this is not the case; and on this ground it is thought that the potential energy of muscle lies little in its nitrogen compounds, but mainly, if not exclusively, in its carbon compounds. If we could examine or analyse the muscles of a wrestler during a heavy match, where great explosions of contractile material must be constantly taking place, we should find the nitrogenous metabolism but little increased, but there would be a large development of carbonic acid. Whence, then, is the carbon derived which furnishes this carbonic acid?

Before attempting to answer this question we must notice the changes which take place in all muscles after death, or when that peculiar condition called rigor mortis sets in. In addition to shortening and hardening of the muscle, there is an opacity about it which indicates its having undergone a species of coagulation. Then, when the muscle has been submitted to chemical treatment, there is a certain proteid body found in it, named myosin, and this myosin is never found in living muscle. Now myosin is the result of coagulation of muscle plasma, just as fibrin is the result of coagulation of blood plasma, but there is this striking difference between them—in the clotting of muscle there is a distinctly acid reaction, while in the clotting of blood there is none.

"At the onset of rigor mortis," writes Dr. Michael Foster, to whose admirable work on *Physiology* I am greatly indebted, "there is a very large and sudden increase of carbonic acid, in fact an outburst, as it were, of that gas."

This is a startling assertion, and the explanation of it that would probably occur to most minds is that it is due to the sudden oxidation of carbonaceous substances in the muscle. Not so, however, for it is found by experiment that the increased production of carbonic acid during rigor mortis is not accompanied by a corresponding increase in the consumption of oxygen. The muscle of a frog placed in an atmosphere of pure nitrogen will not only give off carbonic acid while it is alive, but will also give it off at the onset of rigor mortis, showing conclusively that, as there is no oxygen present, the carbonic acid cannot be due to the direct oxidation of the muscle substance.

The explanation of the phenomenon suggested is that during rigor mortis some complex body—which, by-the-bye, has never been isolated or its existence definitely proved—containing in itself ready-formed carbonic acid, is split up and the carbonic acid set free, but that the process of oxidation, which led to its formation in the muscle, took place at some anterior date. That the complex body which gives rise to the myosin clot, etc., of rigor mortis is the same stuff that gives rise to the carbonic acid, lactic acid, etc., of a muscular contraction seems beyond dispute; but the difference between them is this: In the living muscle the nitrogenous product of the contraction, unlike the solid myosin, is a soluble proteid, and, as it still contains energy, may in some way be utilised in the economy when the contraction is over. The theory, then, that is generally held at the present day—that of Hermann in regard to muscular contraction—is not that which was formerly taught, namely, that some nitrogenous portion of the muscular tissue underwent disintegration, and by so doing set at liberty the energy which up to that time had been potentially employed in holding together the components of the structure, but that it is effected through the chemical change involved in the splitting up or explosive decomposition of some complex body specially prepared for it, composed of carbon compounds, and that this body is lodged, so to speak, in the interstices of the living framework of the muscle. This is the contractile material that forms the newborn child's capital of potential energy before alluded to—the muscle dynamite, or "inogen," as it is sometimes termed.

It is through the chemical combination of oxygen—oxygen conveyed by arterial blood and stored up in some mysterious way by the muscular substance within itself—with the inogen or carbonaceous constituent of the muscle that oxidation or explosive decomposition is effected. In other words, the living gun is fired off, the result being contraction of the muscle, evolution of heat, and the setting free of carbonic acid as an oxidation product.

As that form of energy—or mode of motion, as it has been called by Professor Tyndall—which initiates the oxidation of wood or coal and sets it burning is heat, so that form of energy which starts the oxidation of muscle substance and brings about a muscular contraction is, broadly speaking, nervous impulse; but the steps that are taken by the oxygen, from the time that it leaves the blood to the time it issues from the system as carbonic acid are wrapt in obscurity. But we may inquire from whence the carbo-hydrates, that have so much to do with the potential energy of muscle, are derived. In the first place, fats, which have a varied chemical composition, hold a prominent place. Then there are the food stuffs, or sugars and starches, which are ultimately converted into glycogen or animal starch; and there are also various salts brought by the plasma of the blood to the muscle, which, though they do not supply energy, exert an important effect on the irritability of the muscle and its metabolism.

Now glycogen, on account of its intimate relation to the work stuff of muscle and its formation in the liver, deserves a little attention. It would seem that, under a carbo-hydrate diet, glycogen is accumulated in the liver. It is supposed to be manufactured by the hepatic cell, and lodged in its own substance in such a way that, under certain circumstances, it can leave the hepatic cell and re-enter the blood as sugar when required. It is thought that a very large part of a carbo-hydrate meal is absorbed as sugar, and carried to the liver, where it is dehydrated by the hepatic cell into glycogen in a way the reverse of that by which starch in the alimentary canal is hydrated into sugar through the action of the salivary and pancreatic ferments. Sugar, you are aware, is a necessary constituent of the blood, for nearly all the tissues draw upon it for sugar, and yet the proportion of sugar in the blood is about the same when food is being taken as in the intervals between meals. This uniform proportion is accounted for on the supposition that when sugar is abundant, as during an amylaceous meal, the liver takes care of it and stores it up as glycogen, and when there is a want of sugar in the system the liver reconverts some of its glycogen into sugar, and discharges it into the hepatic blood.

In connection with this glycogenic function of the liver I may remind you that when that part of the medulla oblongata of a rabbit, known as the diabetic area of the vasomotor centre, is punctured temporary diabetes is produced. This is supposed to result from a too rapid conversion of glycogen into sugar, for after the puncture the previously stored up glycogen disappears and the blood becomes loaded with sugar. How, in natural diabetes, the excess of sugar in the blood occurs is not clearly made out, but there are probably varieties of diabetes arising from various sources of excess of sugar. It may, however, be taken for granted that the glycogenic function of the liver is subject to the influence of the cerebro-spinal nervous system.

As we have seen that carbon metabolism is the chief source of muscular energy, are we to conclude that, if we wanted extra work done, we should only have to increase the allowance of carbon compounds in the diet? Certainly not, because the muscle must not be viewed as a machine irrespective of its connections with other parts of the body. The condition of the muscle—or, in other words, the amount of energy available in the muscle itself—is, it is true, a great factor as regards the work to be done. The capital of potential energy in the muscle, it is thought, is not all exhausted in the most severe labour. Fatigue—muscular fatigue—is referable chiefly to the condition of the nervous system, and not necessarily to all the muscular energy having been expended. Still, it must be always borne in mind that the power to do work, especially hard and continued work, hangs upon the heart, the lungs, the nervous system, and the body generally. If we look for a moment at the connection between muscular contractions and their effect on the vascular and respiratory mechanisms, we recognise how, in violent exercise, the blood must be robbed of oxygen and loaded with carbonic acid; how, to meet this changed condition, there must be increased activity of the respiratory centre, and as a consequence increased energy of the respiratory movements; how these are accompanied by increased cardiac activity, and a swifter or fuller stream of blood through the lungs. I say we cannot see these changes occur without admitting the necessity for there being such an efficient condition of the heart and lungs as would ensure the concerted action required for the work to be done by the muscles.

At the commencement of these remarks I referred to the expenditure of potential energy for the purpose of acquiring fresh energy, as shown in the infant sucking at the breast, and how essential it was for the performance of the labour of life, which is involved in breathing, that this renewal of energy should be maintained. Permit me to mention a case which is of not uncommon occurrence. Last year I was called to see an infant, twelve days old, which, although considered healthy at birth, had been troubled with constipation. It had been circumcised on the eighth day, and on the tenth there was diarrhœa, and a strophulous rash on the skin. Two days after the child evidently was fast running down; its face was pinched, it was exceedingly weak, and passing eleven or twelve chopped-spinach stools in the twenty-four hours. It had been fed on humanised cow's milk, with a few drops of brandy; but, as no improvement had taken place on the following day, a healthy wet nurse was obtained. It was now thought the difficulty, as is frequently the case, had been surmounted; but not so. The child had become too weak to suck, it could not grasp the nipple. Its stock of potential energy was practically gone. The respiration must, ere long, cease unless the child's energy could be renewed. How is this to be effected? Only by the conveyance of appropriate food in some way to the digestive tissues or those servants which wait upon the muscles and nerves to enable them to furnish the energy required. Some of the breast milk, to which a few drops of brandy were occasionally added, was from time to time cautiously poured down the child's throat, and, in twenty-four hours, the improvement was marked, the rash soon disappeared, and in the course of a week the child was visibly filling out, and looking plump and healthy.

We must not forget that food supply, necessary as we have just seen it to be for carrying on life, is equalled in importance by those organs being in a good working condition, whose duty it is to eliminate the waste products of metabolism.

It is not easy to follow the food, closely, from its entrance into the body to what is eliminated of it as waste products, but it may be said in general terms that the proteids, fats, carbo-hydrates, together with salts and water, which compose our food, leave the body as waste products, under the form of urea, carbonic acid, salts and water, and that the principal channels by which this most important process is carried out are the lungs, the skin, and the kidneys.

"The lungs serve as the channel for the discharge of the greater part of the carbonic acid and a considerable quantity of water. Through the skin there leave the body a comparatively small quantity of salts, a little carbonic acid, and a variable but on the whole large quantity of water. The kidneys discharge all or nearly all the urea and allied bodies, the greater portion of the salts, and a large amount of water, with an insignificant quantity of carbonic acid. They are especially important since by them practically all the nitrogenous waste leaves the body."

Although the source of animal heat is to be traced to the katabolism or destructive oxidation of every tissue of the body, there is no doubt that the muscles, from their bulk and the characters of their metabolism, are to be regarded as the chief sources of heat. In the total energy expended in a muscular contraction, the ratio of that which appears as work done to that which appears as heat is variable; but it is thought that it ranges from about one-fifth to one twenty-fourth of the total amount. We must remember there is one muscle which never rests and does more work than any other in the body—the heart. Its contribution of heat, according to the energy set free by it in the form of work, must be very large. It is calculated that the work done by the ventricles of an ordinary man's heart in the course of a day is about the same in amount that he would have to perform in making the ascent of Snowdon.

But in addition to a chemical and thermal change taking place when a muscle contracts, there is a remarkable one of an electric character, which is supposed to be intimately connected with the irritability of the muscle, for it is found that these muscle currents, as they are called, diminish and disappear as the irritability of the muscle declines.

Some years ago I removed a portion of a needle which had been embedded in a woman's finger upwards of two years. This piece of needle, which is still in my possession, was found to be, and still remains, unattracted by an ordinary magnet, but easily attracted by a piece of steel, showing that it has become magnetic. Was it in some way rendered magnetic through the agency of these electric muscle currents in the living body?

In regard to the setting free of energy by muscular contraction, it may be stated broadly that the amount of contraction may be taken as a measure of the strength and amount of nervous impulse inducing it, but that no difference can be detected between the nature of an impulse originating spontaneously in the central nervous system, and one excited by electric currents or mechanical stimuli.

Another fact worthy of note is that a muscle is excited to increased action by increasing the work it has to do. Thus if a muscle raised a given weight to a certain height it would be naturally thought that, if the weight were doubled, it would raise it to only half that height, but this is not so. It is supposed that the stimulus of the increased weight leads to a more perfect explosion of the inogen in the muscle. Of course this is within limits, for it is obvious that there must be a point when no stimulus, however great, would enable the muscle to raise the increased load at all. And this remark is applicable to the heart as a muscle, for a full ventricle will contract more vigorously than one not so full, but an overdistended ventricle may cease to beat altogether.

As evidencing the independent irritability or sensitiveness of muscle, it may be observed that when the sciatic nerve is divided its irritability, owing to degenerative changes, soon disappears, but as long as six or seven weeks afterwards there may be muscular hypersensitiveness, although the muscle may have lost all its connection with the nerve. Now muscular fibre, as a rule, responds like a nerve to an electric current, but it is more sluggish than nerve, and requires to be acted upon for a longer time, so that a constant current will induce contractions in a muscle deprived of its nerve connection when a transient induction shock will not. The condition of nerves supplying a muscle may be determined in medical practice by this test, inasmuch as if they have not lost their irritability the muscle as a whole will respond to single induction shocks, but if they have lost it the muscle will not so respond, although it may be easily thrown into contraction by the constant current.

Blood supply is an important factor in maintaining irritability of both muscles and nerves. When the abdominal aorta is ligatured the muscles of the lower limbs lose their irritability and become rigid. So when the circulation ceases, as at death, the same event follows in all the muscles of the body, although it should be noted that rigor mortis occurs in a fixed order, beginning in the jaw and neck first, then in the muscles of the trunk, then the arms, and lastly the legs.

The sense of fatigue after prolonged exertion seems, as I have before remarked, to be referable to the nervous system, and, after the greatest exhaustion of the muscles, recovery takes place on rest. Perhaps nothing more rapidly produces muscular exhaustion than tetanus, and I have a distinct recollection of a case of traumatic tetanus in a young man where violent contractions were induced by touching the wound with a probe, but, after a short time, exhaustion would supervene, when further excitement ceased to have any effect, and yet, on waiting some minutes, the spasm could be reproduced by the same stimulus.

Again, in contractions during labour, the uterus requires intervals of rest, and it is of common occurrence for a stronger pain than usual to follow a longer than usual interval of rest. Whether, in cases of temporary exhaustion, the effect is produced by all the contractile material being used up, or by the accumulation of waste products in the tissues, or by both causes, may be open to conjecture.

Many other points of interest connected with the muscles must be passed over. As regards the nervous system proper such a wide field is opened up by it, and the remarks I had prepared in reference to it would occupy so much space that I am reluctantly compelled to defer the consideration of them altogether to some future opportunity.

ON MINERS' NYSTAGMUS.

By SIMEON SNELL,

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After reading my paper before the Ophthalmological Society, in 1884, on Miners' Nystagmus, I wrote in the pages of the British Medical Journal a letter, in which I earnestly solicited information from medical men attached to coal pits, and from others who might be interested in the affection, which would tend to elicit the truth whether it supported my observations or not. I concluded by saying: "My desire for facts is not merely to support the views I have expressed, but to arrive at the truth."

I have since availed myself of every opportunity to gather information which would aid in elucidating this, to me, most interesting malady. The result of all my investigations has been to corroborate in the fullest manner the observations I have previously published. It is my purpose in this article to set forth evidence in support of my contention that the prime cause of miners' nystagmus is to be found in the constrained attitude a certain proportion of the workers in a coal pit are compelled to assume at their work, and to show also how the question of safety lamps and illumination can only occupy a secondary position.

My conclusions are derived from an experience of more than 500 colliers, who have at different times been under my care for nystagmus, and I have records of 120 cases with which I propose specially dealing in this paper. Many points of interest and importance will have to be omitted, or mentioned very briefly, for want of space.

For the proper understanding of the subject a knowledge of the working of a coal mine is almost necessary; but, for its thorough investigation, it may be safely asserted that an intimate acquaintance with the detailed working of a pit and the different ways which men are employed underground is of the first importance. With this end in view, I have not only obtained the assistance of Government mine inspectors, managers, and other officials, as well as the kindly help of many colliers themselves, but I have been down into the coal pits, seen the men at their work, and have by all these means become familiar with the interior of the mine and the various kinds of work in which the men are engaged.

The nature of the peculiar oscillations of miners' nystagmus I have previously described.[1] The ocular movements of a to and fro, and rotatory character are associated with apparent motions of objects, and the manner in which the collier so affected sees his lamp dance or spin round, has, I think, a great deal to do with his impression that the "safety lamps" are the cause of his malady. The worker with candles also makes a similar complaint as to the motions of his lights.

The original Davy lamp consisted of a cylinder of wire gauze encircling a light whose illuminating power was considerably below one-fifth of a standard candle. Dr. Clanny introduced the use of glass for the lower part in place of the gauze, and these lamps have been used for many years. Further advances in the illuminating powers of safety lamps have also been made, and the Royal Commissioners on Accidents in Mines, who reported in 1886, speak favourably of the Marsaut lamp. This lamp is one of the four recommended by the Royal Commission, and is largely employed in the Midland district. Such a lamp gives two-thirds of the light of a standard candle, and three times and a half the light of a Davy. In the modern safety lamp the gauze is bonneted by a sheet-iron casing, which not only protects it from strong currents of air, but causes the flame to burn with a steadier and more uniform light. I know the miners object to the shadow cast by the bonnet, among other things, of the safety lamp; but

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[1] *Ophth. Soc. Trans.*, 1884.