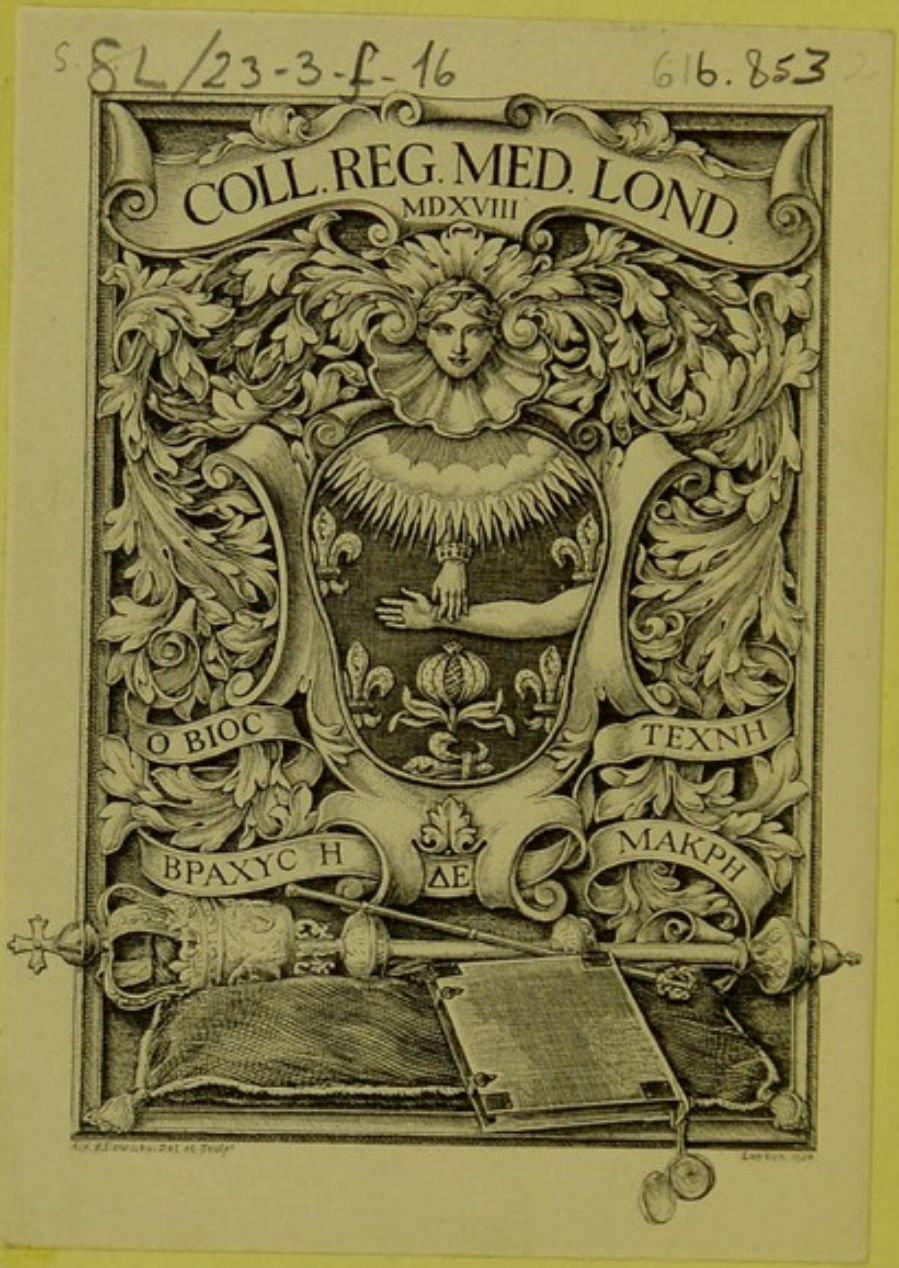
Epilepsy and other affections of the nervous system which are marked by tremor, convulsion, or spasm : their pathology and treatment / by Charles Bland Radcliffe.



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EPILEPSY

AND OTHER

AFFECTIONS OF THE NERVOUS SYSTEM

WHICH ARE MARKED BY

TREMOR, CONVULSION, OR SPASM;

THEIR

PATHOLOGY AND TREATMENT,

BY

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INTRODUCTION.

In the following pages I have prefaced what I have to say upon epilepsy and the cognate disorders by an exposition of the views which I hold upon the physiology of muscular contraction. I have done this because the experience of the last few years has convinced me that the pathology may be misapprehended for want of the physiology, and the physiology for want of the pathology, and because I know of no shorter or better way by which I can hope to demonstrate the changes in theory and practice which appear to be necessary in the subject under consideration.

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PART I.

PRELIMINARY CONSIDERATIONS

RESPECTING THE

PHYSIOLOGY OF MUSCULAR CONTRACTION.

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PHYSIOLOGY OF MUSCULAR CONTRACTION.

Muscular contraction is manifested in three principal forms—in ordinary muscle, in the coats of vessels, and in the heart. It is caused in each case by certain vital agencies and by certain physical agencies. In order, therefore, to a full acquaintance with the nature of the phenomenon, it is necessary to consider it as manifested in each of these forms, and to examine each form as acted upon by both kinds of agency.

CHAPTER I.

MUSCULAR CONTRACTION AS MANIFESTED IN ORDINARY MUSCLE.

Ordinary muscle is of two kinds, voluntary and involuntary, and each kind is endowed with a very remarkable faculty of contraction. This faculty is supposed to be called into exercise by certain *stimuli*, but such a

supposition does not bear the test of examination. Indeed, many doubts as to its correctness are self-evident, and among these the more obvious are those which are suggested by *rigor mortis*, and by that contraction which occurs in the muscle-like tunic of the dartos under the influence of cold.

Rigor mortis, or the contraction which sets in after death, does not appear to be the result of any vital stimulation. It cannot, as is generally supposed, be referred to some lingering vitality in the muscles, for the time of its accession and the degree of this vitality are inversely related to each other;—it occurs soonest, that is to say, in muscles whose strength has been previously exhausted by old age or by chronic disorder such as consumption, and delays longest in muscles whose strength is retained at death, as in the case of persons who have been cut down in the full vigour of health. The time of accession, indeed, coincides with the departure of animal heat, and this departure is longest deferred under the latter circumstances. This contraction is also counteracted by the stimulus of the circulation, for, after it has existed some length of time, the muscle may be made to relax and recover its lost irritability by the injection of warm blood. M. Brown-Séquard has recently demonstrated this fact by numerous experiments.

The dartos, as is well known, contracts under the influence of cold and expands under the influence of heat—in other words, it contracts in absence of the stimulus of heat, for cold is only the absence of that stimulus.

Nor is the difficulty removed by supposing that the

contraction which occurs under these circumstances is the result of *muscular tonicity*, for there is every reason to agree with Dr. Todd and Mr. Bowman in believing that the slow and gradual contraction which belongs to this property is identical in nature and origin with the sudden, transient, and more characteristic contraction of *muscular irritability*.

Similar doubts might be suggested, but these are sufficient to challenge a strict and systematic examination of the whole question of muscular contraction.

— In entering upon this examination it is desirable to determine the mode in which muscle is affected by natural and vital agencies before proceeding to investigate the influence of those physical and artificial agencies which are concerned in the matter.

1. On comparing voluntary and involuntary muscles their contractibility is found to be related in an inverse ratio to the supply of nerves. Involuntary muscles are far more sparingly supplied with nerves than voluntary muscles, and yet their power of contraction, as measured by its duration, is indefinitely greater. Muscular contraction, again, is found to be a more marked phenomenon in reptiles, and in other creatures whose nervous centres are sparingly developed, than in animals higher in rank, and more liberally endowed with these organs. These facts, which are not to be doubted, seem to point to nervous influence as antagonising rather than as inducing muscular contraction;—at all events they seem to show it as *unnecessary* to contraction.

On instituting a further comparison between voluntary and involuntary muscles it is found that the power of contraction, as measured by its duration, is related in a similar inverse proportion to the supply of blood. Mr. Bowman has shown that the number of capillary vessels in a muscle corresponds very closely to the number of elementary fibres; and hence involuntary muscles, whose fibres are much fewer and coarser than the fibres of voluntary muscles, and whose disposition and power to contract is far greater, but whose individual capillaries are smaller rather than larger, have a much scantier supply of blood. Reptiles, and other animals whose muscles are distinguished by their continued contractions, have pale and comparatively bloodless muscles. Hybernating warm-blooded animals, whose muscles acquire for the time a reptilian continuousness of contractibility, have a circulation, the activity of which is barely consistent with life. It is to be remembered, also, that muscular contraction becomes excessive, and takes upon itself the form of convulsion, as an animal bleeds to death at the shambles; and that *rigor mortis* may be relaxed,—as in the experiments of M. Brown-Séquard, by the injection of warm blood into the vessels. All these facts apparently show that contraction is due to the absence rather than to the presence of the stimulus which is derived from the blood.

So far, then, there is no reason for supposing that muscular contraction is the result of vital stimulation, and there is some reason to the contrary.

2. The physical agencies which have the power of inducing muscular contraction are irritation by simple

contact, electricity, cold and heat, light, and certain chemical and medical substances; and each agent presents a problem which demands patient and attentive consideration.

(*a.*) A muscle is said to be irritated to contract by the simple contact of certain natural or artificial substances—the bowel by the food, a detached fibre by the point of a needle—and how is this? What is the influence at work, and what is the manner of the operation?

It is difficult to acquiesce in the common belief that the hollow involuntary muscles are *excited* to contract by their natural contents. If the morsel exerts this influence on the gullet, how can it effect an entrance? Or if effecting this, how is it that it is not fixed immoveably in one place? There is no physical necessity why the movements should follow in any certain and definite order. On the contrary, the morsel may move upward or downward indifferently, as it is seen to do in the throat of a cow during rumination. Indeed, so far from exciting contraction, it appears as if the food remained quietly in the stomach, and in every other part of the alimentary canal, until the digestive process is complete, and that contraction *happens* when those molecular changes are at an end which could have acted as a stimulus to the muscle.

It is so, also, with regard to the uterus and the fœtus. For nine long months the fœtus has gone on exciting the uterus to expansive growth, and how, then, can it be supposed to turn round and excite it to contraction at

the end of this time? The probabilities, as measured by time, are those of nine months to as many hours, against such a view. Apart, indeed, from theory, the probabilities are that the fœtus grows and causes the uterus to expand by the stimulus of its living presence, and that it does this until the growth begins to trench upon the supplies which are necessary for the proper nourishment of the mother. Then the child becomes a source of exhaustion to the parent, and this exhaustion, reacting upon the uterus, brings back the state of contraction;—for if the uterus went on expanding in consequence of stimulation it must needs return from that state of expansion if the degree of stimulation be diminished, and this equally whether the diminution be occasioned by the death of the child, or whether it be the result of the child having lived until it begins to starve the mother by its too-clamorous wants. In either case contraction must happen, and certainly in the latter case, for the uterus being a part of the mother, her life must have contributed to the stimulation which had kept up the previous state of expansion. The contraction compresses the placentary vessels, and depresses the life of the fœtus by interfering with the proper aëration of its blood; and this depression extending to the uterus, is followed by an equivalent degree of contraction. This contraction, like the first, compresses the placentary vessels, and depresses the life of the fœtus by interfering with its respiratory processes; and this depression, extending to the uterus, is followed by an equivalent degree of contraction. Again and again contraction leads to

contraction by the same process; and in this way the uterus acts upon the fœtus, and the fœtus reacts upon the uterus, with ever increasing contraction as the result, until the completion of birth. At all events, it is impossible, upon any rational view of parturition, to refer the contraction of the uterus to any *stimulation* on the part of the fœtus, without ignoring the whole previous history of pregnancy.

A similar process of reasoning is applicable to the contraction of the bladder, and of other contractile and hollow viscera, but these instances must suffice.

It is equally difficult to acquiesce in the common belief that a muscle is *excited* or *irritated* to contract by the simple contact of the point of a needle, or of any other foreign body. It is difficult to do this, and at the same time to remember the analogies which are known to exist, not only between the contraction of a muscle and the discharge of the electrical apparatus of the torpedo, but also between the organic structure of the muscle and that of the apparatus. These analogies lead to the *impression* that the needle does not excite or irritate the muscle to contract, but that it procures an electrical discharge similar to that which takes place from the battery of the fish under similar circumstances; and this impression receives strength from the fact (which has been fully demonstrated by M. Dubois Reymond), that electricity is present in the muscle *before* contraction, which departs *during* contraction. It is an easy supposition, and one quite in conformity with the established laws of induction, that the needle may have furnished a channel for

the escape of such electricity, but it is not so easy to believe that it may itself have been an active stimulus. This, indeed, is quite at variance with all known laws of force.

(*b*.) The influence of *electricity* upon muscular action is obscured in many ways, but, thanks to the experiments of MM. Matteucci and Dubois Reymond, this obscurity is not impenetrable.

The primary fact in connection with this question is that a living muscle deflects the needle of the galvanometer, produces electrolysis, and affords other evidences of sensible electricity, while it is *at rest*, and that it ceases to evince any sign of such action *during contraction*. This fact—the latter part of which has been recently discovered by M. Dubois Reymond—is of primary and supreme importance; and a full and definite conception must be obtained respecting it before proceeding to investigate the influence of artificial electricity upon muscular action.

During rest, then, it is found that an electrical current passes between the end and side of the irritable muscular fibre. Experimenting upon the adductor magnus of a frog, the needle of the galvanometer gave no indication of a current when the electrodes were placed in contact with the two ends simply, or with the two sides simply; but it was immediately deflected when one electrode was applied to the end, and the other to the side of the muscle. This current passed indifferently from the end which happened to be in contact with the electrode, and hence it was not absolutely and constantly of one

direction in the muscle. This law was found to obtain in large muscular masses, and in small fragments—even in single fibres. In the natural and living state, however, the current would seem to have,—under ordinary circumstances at least,—a constant direction : thus, in the leg of the frog it is from the foot upwards, and in the arm of man from the shoulder downwards—these differences, in all probability, being the result of the different form and arrangement of the muscles composing the limbs, of the special currents of which muscles the general current of the limb is the resultant. This general current, however, is reversible under extraordinary circumstances, (as in the leg of the frog when frozen,) and of this reversal the explanation would appear to be as follows :—The muscular and tendinous portions of the muscle both participate in the production of the electrical action, but the former portions much more decidedly than the latter. This action is depressed and finally extinguished by cold, and, according to M. Dubois Reymond, that of the muscle first. If, then, under ordinary circumstances, the current sets in a given direction *because* the action of the muscle is greater than that of the tendon, it follows that the direction will be reversed, when, under the influence of cold, the circumstances are so changed that the action of the muscle is less than that of the tendon. It would be so, if, in an ordinary galvanic battery, plates were substituted in place of the zinc, whose relative molecular activity was *lower* than that of the copper. This appears to be the explanation of the reversal of the current in the frog's leg, which takes place under the influence of

cold; and hence there is no reason to agree with M. Dubois Reymond in regarding it as anomalous.

The remarkable disappearance of the signs of electrical action *during muscular contraction* is best investigated in muscles which have been *tetanised*, or thrown into a state of permanent contraction, by electricity or strychnia, or by any other means. Indeed, it is extremely difficult, if not impossible, to catch the true indications of the needle of the galvanometer in any single and rapid act of contraction.

The gastrocnemius muscle of a frog with a long portion of the main nerve attached, a delicate galvanometer, and an electromotor apparatus capable of furnishing a series of alternating shocks, must be provided. The muscle is then placed between the poles of the galvanometer, with one pole to its end and the other to its middle,—the nerve is laid across the poles of the electromotor apparatus, —and the preliminary arrangements are complete. The muscle is thus included in the circuit of the galvanometer, and the needle of that instrument furnishes immediate proof of any change in the muscular electricity. The nerve, on the other hand, is under the influence of the electromotor apparatus, and by this influence, acting through the nerve, the muscle may be tetanised at pleasure. The movements of the needle are then observed before and during contraction; and on doing this it is found that the needle is deflected to some distance from zero, when the muscle is at rest, and that it returns to zero, or towards zero, when contraction is induced. This is M. Dubois Reymond's fundamental experiment.

Now this return of the needle to zero, or towards zero, is not owing to any irruption of the current of the electromotor apparatus into the circuit of the galvanometer; nor is it owing to the action of a current contrary to that which had acted when the muscle was at rest.

It is not owing to the irruption of any current from the electromotor apparatus into the circuit of the galvanometer, for the circuits of the two instruments are perfectly distinct. The current of the electromotor apparatus passes through the portion of the nerve included between its poles, and the action thus excited in that portion *induces* action *secondarily*, in the portion of the nerve beyond the circuit, and this induced action is communicated to the muscle, but the current of the instrument does not pass through the muscle. This is proved by the fact that any mere conductor, such as moist thread or paper, or even the nerve itself after its irritability is at an end, is not sufficient to convey the influence of the electromotor circuit to the muscle. It is proved also by the fact that the needle moves equally to zero or towards zero when the muscle has been tetanised by other means than by electricity, as by strychnia, or by burning, crushing, or otherwise injuring the extremity of the nerve.

Nor does the needle of the galvanometer return to zero or towards zero in consequence of the action of a current contrary to that which has acted during the rest of the muscle. The current during rest would naturally produce such a contrary current by inducing secondary polarity in the terminal platinum plates of the galvano-

meter, and this secondary current would begin to operate as soon as the primary current was at rest:—but means are taken to obviate this source of fallacy. Everything else being arranged as in the former experiment, two amalgamated copper wires are connected with the platinum plates of the galvanometer, and their ends bent in such a way that they could be easily dipped into or removed from a small cup of mercury. When both these wires are in the mercury the circuit of the galvanometer is complete, and the polarity of that circuit immediately destroyed, if such existed; when one wire is removed from the mercury the galvanometer is under the influence of the muscle as before. The galvanometer being thus modified, the former experiment is repeated. The zero point of the needle, the degree of *de*flection of the quiescent muscle, and the degree of *re*flection by the tetanised muscle, are carefully noted. The muscle is then tetanised, and while it is in this state the galvanometer is depolarized and its needle restored to zero by dipping the copper wires into the mercury. The muscle being still tetanised, the wires are then removed from the mercury, and the galvanometer restored to the influence of the muscle. In this instance, therefore, the needle indicates the current of the tetanised muscle, just as in the first instance it did that of the untetanised muscle, and this indication is—*that the needle moves in the same direction but not to the same degree.* The current is of the same kind but feebler in intensity. This experiment, therefore, is quite conclusive as to the non-existence of a contrary current in the

tetanised state, and this equally whether that current be supposed to arise in the secondary polarity of the platinum plates of the galvanometer, or in corresponding changes in the molecular texture of the muscle itself; and it is equally conclusive as showing that the reflection of the needle towards zero during contraction is owing to an actual *decrease* in the electrical action previously existing.

M. Dubois Reymond has also obtained proof of a similar decrease in electrical action during the muscular contraction of the living human arm. The experiment is performed by dipping the fore finger of each arm into the vessel containing the terminal plates of the galvanometer, and by then contracting each arm successively, every precaution being taken to obviate any irregularities of action arising from abrasion of the skin and from other causes, by having each finger as nearly as possible in the same state. When the arms are at rest, their respective currents being opposed to each other, the needle of the galvanometer remains at zero or thereabouts; but when either arm is contracted, the needle immediately becomes deflected towards that arm,—it moves, that is to say, from the arm which is at rest, and in obedience to the electrical action of that arm, which action comes into play in consequence of the neutralization of the opposing current in the other arm.

The needle also moves towards zero in cadaveric rigidity, and the conditions of movement are the same, for at this time, and for ever afterwards, all electrical action is at an end.

These experiments are of extreme importance and

significance; and they are the more important and significant because their author makes and relates them as mere facts, and independently of all theory. Indeed, to him they appear to have no significance whatever.

— It now remains to inquire into the influence of artificial electricity upon muscular contraction, and in order to this, a simple experiment of M. Matteucci will furnish a sufficient text.

Take a simple galvanic cell, and the skinned hind leg of a frog, and apply one pole to the end of the thigh and the other to the foot. If the poles be so arranged that the current is from the foot to the thigh, a slight contraction happens on closing the circuit, and a violent one on breaking it; if, on the other hand, the poles are reversed, and the current be made to pass from the thigh to the foot, there is a violent contraction on closing the circuit, and a slight one on breaking it. The slight contractions only continue for a short time, but the violent contractions remain until the muscular irritability is exhausted.

Now in analysing this experiment, it must be remembered that there is a natural current from the foot to the thigh, and remembering this, the explanation is not difficult.

What, then, is the influence of the artificial current in relation to the *violent* contractions? When the artificial and natural currents pass in the same direction, each current must intensify the other, and yet the contraction does not happen until the artificial current is *suspended*. When, on the other hand, the artificial and natural

currents pass in opposite directions, and the one must neutralize the other, the contraction happens during *the time of neutralization*. It is coincident with the negation of electrical action.

With regard to the *slight* contractions, the explanation is somewhat different, but it is not at variance with that just offered. The fact that they coincide in point of time with the short period during which muscular contraction may be induced through the nerves, and not with that longer time during which it may be induced by the direct application of agents to the muscle itself, is an argument that these slight contractions are related to changes which have reference to the nerves, rather than to the muscles. Now, the nerve in the case in question is a mixed nerve—a nerve, that is to say, whose fibres convey the nervous influence, some in one direction and some in another. All that is necessary, then, is to *assume* that this nerve has double electrical, as well as double nervous currents, and the explanation is easy. When the slight contraction takes place on the closure of the circuit, then the artificial current will have neutralized the electrical currents which traverse the nerve from the head to the foot; and when, on the other hand, the slight contraction takes place on the rupture of the circuit, then the excitement of the artificial current will have been removed from those nervous fibres with the electrical currents of which it had previously coincided and co-operated. In this way the history of the slight and transient muscular contractions coincides with the history of the more marked and continuous contractions, already

mentioned, and the one supports and confirms the other. Nor is this explanation of the slight and transient contractions entirely hypothetical. M. Dubois Reymond has demonstrated the electrical activity of nerves, and the cessation of this activity during muscular contraction. The disappearance of the slight contractions along with the excitability of the nerve, and long before the cessation of the contractability of the muscle, is a fair argument that these contractions are related to the nerve rather than to the muscle. And if double electrical currents have not yet been detected in mixed nerves, the existence of double nervous currents in these nerves, is no small argument that they will be detected eventually.

All other experiments bearing upon the question are capable of the same interpretation, and there is not one of them which is at all explicable on the supposition that muscular contraction is *excited* by electricity.

In a word, these experiments of MM. Dubois Reymond and Matteucci necessitate a complete revolution in the theory of muscular contraction, so far as the influence of electricity is concerned,—the former as proving that this contraction is accompanied by the disappearance of the innate electricity of the muscle and nerve, and the latter as showing that artificial electricity induces contraction by diminishing or neutralizing, and not by intensifying, this innate electricity.

(*c.*) Cold and heat are spoken of indifferently as exciting muscular contraction, though how cold and heat should act in the same way, and how cold should be an excitant, does not appear very clearly. Little is known of the

action of heat in these respects, but that little serves to show that this agent is not a cause of contraction. Cold cramps and stiffens the hands; warmth relaxes them. Cold water crimps, or in other words cramps, the flesh of fishes. Nor is it correct to say that heat is produced during muscular contraction. It is produced during muscular *action*, as during the act of sawing, but this action consists of alternate relaxations and contractions. It is possible, therefore, that the heat may be due to the relaxations,—nay, it is probable, for when the limb is wearied and the action over, and when the temperature is highest, the muscles are relaxed. The fact, also, that the heat originating under these circumstances continues for a long time after the exertion has ceased is an argument that it is due to some other cause than muscular contraction.

(*d.*) Nor can light be said to excite contraction, though in the case of the iris it seems to do so. There is no doubt that light excites the reverse of contraction in the irritable cushions connected with the leaves of the sensitive plant; and there is some reason to believe that it acts similarly upon the iris. Bichât was of opinion that it acted in this manner, and that closure of the pupil was caused by the expansion of the entire curtain of the iris, and not by the contraction of its inner rim; and it is a strong argument in favour of this opinion that it harmonizes with what is known of the action of light upon the irritable tissues of the sensitive plant, and of other plants.

(*e.*) Nor can chemical agents be said to excite contraction.

The air is said to excite contraction in the muscles of the air-passages, but in reality the air is drawn into the chest and kept there until it has lost a great portion of its stimulant properties. It seems to stimulate expansion if it stimulates anything; and all the more seeing that these tubes, and the entire chest, remain contracted until the moment of birth. It may be objected, however, that the lungs are filled or emptied in consequence of the movements in the walls of the chest, and that the seeming dilatation of the air-passages is due to the entrance of the atmosphere into the vacuum caused by the descent of the diaphragm and by the raising of the ribs; but the answer to this objection is that the air-passages will not fill with irrespirable air—with air that is not stimulant. It may be objected that the air-passages contract in consequence of the *stimulus* of carbonic acid, but it is not easy to admit this gas into any category of stimulants. The fact, however, that the air-passages remain quietly and continuously contracted before birth is the main reason for supposing that that contraction is not dependent upon any active property in the air.

Little is known with regard to the influence of other chemical or medical agents upon muscular contraction, and that little is very fragmentary. With regard, however, to the two principal agents belonging to this class—opium and strychnia—there is no reason whatever for supposing them to act as stimuli. How strychnia acts will be seen hereafter, when speaking of tetanus.

On the other hand, chloroform, ether, alcohol, and some other agents which are manifestly stimulant,

cause decided relaxation in the muscular system when they are introduced into the circulation.

— It appears, therefore, that physical and vital agents exert a similar kind of action upon ordinary muscle, and that they *stimulate* the reverse of contraction if they stimulate anything. It appears, indeed, as if this action antagonised the ordinary molecular attraction of the muscle so long as it lasted, and that contraction took place by means of the molecular attraction when the action ceased;—and that it does so may be argued from the character of the motion.

It is supposed that this *motion* is different from that which would result from molecular attraction, and an experiment by M. Schwann is cited in support of this opinion. That physiologist argues that if muscular contraction were due to ordinary molecular attraction it would become greater and greater as the molecules approximated; and because he found, on measuring the force of contraction in the muscles of a frog's leg at different degrees of contraction, that the force decreased as the muscle contracted, he concluded that the force concerned could not be that of molecular attraction. But he curiously overlooks a very obvious element in the calculation, and forgets to estimate the effects of *resistance* in counteracting the attraction of the molecules. He reasons as if the muscle and the apparatus employed to test the contraction did not exist; and doing this his whole experiment falls to the ground, except it be retained to show the very opposite of that for which it was intended—namely, that the pure law of

attraction, as seen in muscular contraction, is masked and antagonised by the material resistance of the structure in which it is manifested.

Contraction, then, as seen in ordinary muscle, would appear to be analogous to that contraction which takes place in inorganic bodies on the abstraction of heat, with this only difference that more forces have to be abstracted from the organic than from the inorganic body. The analogy is indeed perfect; for even that remarkable degree of contraction which is witnessed in muscle as compared with that which is seen in inorganic bodies, may be a natural consequence of the physical constitution of muscle; for as muscle is composed almost exclusively of certain gaseous elements, it *may* contract to a great degree under a small abstraction of heat, because it is the law of its constituent gases, as gases, so to contract.

CHAPTER II.

MUSCULAR CONTRACTION AS MANIFESTED IN THE COATS OF VESSELS.

As in ordinary muscle so in the coats of vessels, muscular contraction is supposed to be the work of various vital and physical stimuli, and this supposition is based upon a similar kind of evidence.

1. In many instances, however, the condition of the capillaries is directly opposed to the idea that the vital stimuli act upon these vessels as causes of contraction. Joy flushes the skin and fear blanches it;—in other words, the superficial capillaries expand when the nervous energy is exuberant, and shrink when it is deficient. When the blood is rich and stimulating, as in plethora, the vessels are red and full; when it is poor and watery, as in anæmia, they are shrunk and empty. And so also in regard to the respiration, the arteries and capillaries are fullest when the aëration of the blood is most perfect, and when the vitality of the system is roused to the highest degree. The vessels, indeed, seem to dilate in direct proportion to the amount of vital force expended upon them. With regard to respiration this is intelligible, for the force originating in this function—

in part at least—is *heat;* and so also with the force originating in nutrition and innervation,—for there is no doubt that the exercise of these functions involves the extrication of an equivalent degree of *heat.* It is intelligible, because heat must exercise an expansive influence upon the vessels. But be this as it may, it is perfectly clear that the phenomenon of contraction in the capillary vessels, in so far as it is related to the vital stimuli which have been mentioned, is due to the absence and not to the presence of these stimuli.

2. Judging from the effects of heat, which are easily determinable, the action of physical stimuli upon the coats of vessels is not different from that of vital stimuli. If the hand be held to the fire it becomes flushed; if exposed to cold it becomes pale. Of the influence of the other physical agencies little is known, but that little is in no way contradictory to what has been said of their action upon ordinary muscle.

— Upon this view of the action of physical and vital forces on the vessels, a clue is obtained to the explanation of those phenomena in the circulation which are independent of the heart.

If heat, and the agents associated with heat, excite expansion in the vessels, it is easy to understand how they must give rise to a force—a "*capillary force*"—which is independent of the heart; and how they must co-operate with the heart in facilitating the progress of the blood through the vessels of the living animal in precisely the same way as the warm bath co-operates with the injecting-syringe of the anatomist in procuring the

admission of the melted wax into the vessels of the dead animal. It would be different if the vessels acted upon were composed of ordinary solids, for then the heat would cause a greater degree of expansion in the fluids contained within the vessels than in the vessels themselves; but, in reality, the vessels are gases, *coerced* into solidity for the time, rather than ordinary solids, and being so, they may be expected to be more affected by heat than fluids whose chief constituent is water. And so they are, for the changes which are wrought by slight variations of temperature in the areolar tissue of the skin, in the dartos, and in the coats of the superficial vessels, are infinitely greater than those which occur in any known fluid under the same circumstances —so great as only to be explicable on the supposition that the solids acted upon remember and obey the law of expansion which belongs to their constituent gases as gases. There is, therefore, no difficulty in supposing that heat may favour the admission of blood into the vessels by enlarging their channels; and not only so, but there are grounds for believing that the expansion will be so great as to leave certain *vacua* between the vessels and the fluids contained within them, and that these vacua will—as it were—constrain the blood to enter into the vessels. In this way it may be understood how the warm blood should contribute to its own movements after it has left the heart, and how there should be a "capillary force" of great power which is altogether independent of the heart.

On the same principles it is easy to understand how a

vessel which has become *over*-expanded by heat, or by any other agent, should go on expanding and expanding under the warmth of the blood admitted into it until it has run into a state of *inflammation*. The blood enters in to occupy the vacua caused by the expansion, and having entered, it augments the expansion and multiplies the vacua, by its own warmth. These new vacua necessitate the admission of new supplies of blood, and the warmth of this blood provokes further expansion, and produces other vacua. Again, blood enters and occupies the empty spaces, and again and again the same process is repeated, until the vessel bursts, or until further expansion and absorption is put an end to by the pressure of surrounding parts. In this way the active determination of blood into the vessel appears to be the necessary and natural result of the reactions existing between the warm blood and the vessel receiving it —provided the vessel be so much expanded in the first instance that the molecular attraction of its coats is rendered insufficient to resist the expanding influence proceeding directly and indirectly from the warmth of the blood;—and this active determination of blood is the chief difficulty in the process of inflammation, for if it be accounted for, all the changes which take place in the blood soon meet with their explanation.

On the same principles it is even easy to understand the cause of those curious ever-shifting to-and-fro movements which are seen in the contents of vessels before the formation of the heart, and which are permanent in the laticiferous vessels of the plant, if it be granted—as it

must needs be—that the lymphy or milky contents of these vessels have some degree of that inherent heat-producing faculty which belongs to the blood. These *fugitive hearts*, as these ever-shifting centres of fluctuating movement may be called, occur in a vascular web, the vessels of which are of unequal sizes; and this fact is very intimately concerned in the explanation of the phenomena. Under these circumstances, indeed, it follows as a matter of course that more heat will be produced, and greater expansion caused, in the larger than in the smaller vessels; and for this reason it follows also that the fullest vessels will be most acted upon, and being so acted upon, that they will go on filling and expanding, and expanding and filling, until a stop is put to the continuance of the process by the mechanical resistance of external parts. Then the vessels next in size will become the seats of the same action, and they will go on filling, partly at the expense of the vessels which have already become distended to the utmost, and partly at the expense of the emptier vessels, until they can fill no more. Then the scene of action will change to the vessels next in size;—and so on indefinitely, so long as the field in which the action is manifested consists of vessels of unequal sizes. So long as it consists of vessels of unequal sizes,—for it is manifest that the degree of heat generated, and the degree of expansion produced, must be the same in every part of the web if all the vessels were of the same sizes, and that consequently there would be none of those inequalities of action which are essential to the origination of these fugitive hearts.

CHAPTER III.

MUSCULAR CONTRACTION AS MANIFESTED IN THE HEART.

A SHORT examination of the heart is sufficient to show that there is an active power of dilatation in this organ, and this is, to some extent, a presumptive argument that contraction is a passive phenomenon, as in the former cases.

The sigmoid valves at the outlets of the ventricles are clearly intended to prevent regurgitation of blood during the diastole, and hence they furnish reasons for supposing that the diastole is due either to passive or to active dilatation. That it is not due to passive dilatation may be argued from the absence of all elastic tissue by the resilience of which the heart might be supposed to recover itself after the systole. That it is due to active dilatation may be argued from the state of the heart in insects, and in some other members of the articulate order. In these creatures the heart lies in the general cavity of the body, and floats in the sanguineous fluid with which this cavity is filled. There are no venous trunks to convey the blood into it, but that fluid is

admitted through simple valved slits in the walls. The heart is not a dense muscular organ, as in the higher animals, but it is a lax, membranous tube, little, if at all, superior to the ordinary vessel. Still the beats are not less distinct or rhythmical. The action is perfect, and the conditions are simplified. Here, indeed, the dilatation cannot be the effect of a *vis-a-tergo* filling out a relaxed chamber, for in a heart without veins, and lodging, as it were, *in* an immense auricle, where the blood moves in no definite current, there can be no such force. Here, moreover, the dilatation cannot be due to the resilience of elastic tissue compressed during the contraction, for the walls of the organ are lax and membranous. Here, in short, there seems to be no way in which the heart could overcome the pressure of the surrounding fluid, and become filled with that fluid, except by means of some active power of dilatation.

These considerations furnish a preliminary objection to the idea that the systole is an active phenomenon, for it is not at all probable that systole and diastole are both active phenomena. They show nothing conclusively, however, and hence it is necessary to go over the old ground, and to study the action of the heart in relation to the several vital and physical agencies which are concerned in it.

1. The exact way in which the heart is influenced by nervous agency is not easily determined, but there are several facts from which a not very improbable inference may be drawn. Arguing from what takes place when the nervous energy is more or less depressed, as during

the operation of fear, it may be presumed that this energy is not necessary to the heart's contraction, or systole. Under these circumstances the heart beats hastily, and yet little blood is propelled out of it. The beats are perhaps doubled, and yet the skin is cold and pale. Now, under ordinary circumstances, the double number of beats would propel a double quantity of blood into the vessels, and the skin would be hot and red, instead of cold and pale; and hence the probability that in this apparently anomalous condition of a rapid pulse and a pale skin, the chambers of the heart are diminished in size by the contraction of the walls, and that for this cause they receive and propel less blood than usual.

There is reason, also, for supposing that the systole is always contemporaneous with a lessened supply of nervous influence, and not with an increased supply. The blood escapes from the heart in gushes, and there is some reason for believing that the nervous energy, in some parts at least, is generated in corresponding gushes. At all events, the blood passes by gushes into the great cerebro-spinal masses, and causes corresponding pulsations in them, whenever they are exposed to sight. It may further be supposed that nervous influence is developed and distributed the moment the blood comes in contact with the organ in which it originates, for this influence is sudden and subtle as electricity. All this may be supposed, and, if so, then the heart will be supplied with the gush of nervous influence, not during the systole, but during the diastole.

The effects of the blood upon the action of the heart are more obvious than those of the nervous influence, and these effects are clearly irreconcileable with ordinary views on the subject. The fact, indeed, that the heart remains distended with blood during a full half of the time occupied in its rhythm is a strong argument that the blood does not excite the systole. The histories of plethora and anæmia are to the same effect. In plethora the pulse is full and slow; in anæmia empty and quick. In the one case, the heart fills to distension with rich blood, and the systole is deferred; in the other case, the heart takes in a small quantity of poor unstimulating blood, and expels it immediately. The facts are the very opposites of what they ought to be if the blood excited contraction, for then there should be a small quick pulse in plethora, and a full slow pulse in anæmia. But they are just what they ought to be if the blood provokes the heart to dilatation by its stimulant properties, for then the heart ought to dilate most, and the dilatation to continue longest, when the blood is rich and warm, as in plethora. The fact, again, that the blood gets into the heart at all is an argument that it excites the diastole, and not the systole for there is no *vis-a-tergo* sufficient to overcome the inertia of the thick cardiac muscle, and no elastic tissue capable of causing the diastole by its resilience when the systole passes off. There may be some doubt as to this in the higher animals, but in insects and in many other articulate animals, where, as has been already stated, the heart is an inelastic membranous tube, lying in the midst of the sanguineous fluid, and without veins

through which any *vis-a-tergo* could be directed, there can be no doubt, for in these cases the only way in which the blood can effect an entrance into the heart is by provoking dilatation.

— So far, therefore, the contraction of the heart appears to be analogous to the contraction of ordinary muscle, and of the coats of vessels, and this analogy is a strong argument in favour of this view. But a much stronger argument remains to be stated, and this is the rational and physical explanation which this view affords of the mystery of the heart's rhythm.

Viewing the heart in relation to the nervous influence it has been argued that that influence is supplied more abundantly during the diastole than during the systole. The heart contracts and sends a flood of blood to the great sources of innervation. There, the blood originates a gush of nervous influence, which passing along the nerves to the heart, causes the diastole. The diastole cuts off the arterial stream, and the blood sets in from the auricles and veins. The cutting off of the arterial stream interrupts the development of nervous influence, and this interruption, reacting upon the heart, removes the influence which had caused the diastole, and the systole returns. And so round the same circle. The arterial stream sets out at the systole and developes the nervous influence at its proper sources, and the nervous influence inducing the diastole causes the systole by cutting off the supply of blood, and by thus suspending for the time the active development of nervous influence. And thus, in a regular series, systole gives rise to diastole,

and diastole is followed by systole, so long as the vascular and nervous systems retain their integrity. This is *one* part of the process.

It will be thought, however, that the action of the auricles is directly contrary to this view, for their systole coincides with the ventricular diastole and their diastole with the ventricular systole; but this is no real objection.

It cannot be denied that the auricles have a proper power of dilating and contracting, but it is a fallacy to suppose that the rapid rhythmic movements which alternate with the movements of the ventricles are due to this proper power. There is indeed good reason for supposing that the systole of the auricles is far less the effect of contraction in the coats of the auricles, than of a *falling in* of these coats upon the sudden emptying of the chambers of the auricles by the diastolic suction of the ventricles, and this reason is found in the anatomical peculiarities of the coats and cavities of the auricles. The absence of any valves to prevent the reflux of blood into the veins, and the absence of any such reflux except where patency of the auriculo-ventricular valves allows the systole of the ventricles to propel blood back into the auricles and through them into the veins, affords a very strong argument against the existence of any proper and active systole in the auricles. Comparative anatomy furnishes an argument to the same effect, by showing that the auricles are supply-cisterns for the ventricles, rather than organs destined to aid in the circulation by their contractions. The actual anatomy of the auricles is also opposed to the

idea of sudden rhythmic contraction. It is quite different from that of the ventricles, for though the coats are truly muscular, yet the muscle is of that *unstriped* kind which is found in the coats of the intestines, and not of that *striped* kind which occurs in voluntary muscle, and in the coats of the ventricle. It is, indeed, that kind which is not at all apt to move rapidly, and which is especially slow in responding to nervous influence: and in these respects it contrasts in the fullest manner with the striped muscle of the ventricle, which like other striped muscle, is capable of rapid movement, and very sensitive to nervous influence.

For these reasons, then, it may be argued that the systole of the auricles is due to the *falling in* of the auricular coats upon the withdrawal of blood from the auricular chambers by the diastolic suction of the ventricles, rather than to any proper systolic contraction in these coats. In other words, the blood is not forced away but drawn away, and the auricular systole is *secondary* in point of time to the ventricular diastole. The auricular diastole *may* be more active than the systole, but the peculiarities of structure which prevent rapid contraction are equally unfavorable to rapid dilatation: and it is therefore more accordant with the premises to suppose that the diastole is passive like the systole, and that it is mainly due to the general current of blood, which, proceeding from the pulse and capillary power, sets in from the veins to the heart.

— Viewing the heart in relation to the blood, the causes of the rhythm are still more apparent. At the sys-

tole, the blood is distributed to the arteries, and among the rest, to the coronary arteries of the heart. This blood rushing into the walls of the heart becomes one cause of the diastole, partly by the force of the ventricular injection, and partly by the stimulant properties of the blood itself. At the diastole the arterial jet is cut off, and no new blood being supplied to the heart, that cause of the diastole is suspended, and the systole returns. The systole supplies anew the causes of the diastole, and the diastole by interrupting these causes, brings back the systole, which restores the diastole; and thus systole gives rise to diastole, and diastole to systole, as long as the heart retains its natural dilatability, and the blood its dilating energy.

In this explanation the blood is supposed to act *in* the coats of the heart, and not upon the walls of the chambers; and that it does act in this manner is to be argued from the simultaneous action of both ventricles. Any action of the blood upon the walls of the chambers is not sufficient to account for the simultaneous action of the two sides of the heart, for on one side it is venous, and on the other side arterial. Nor is it sufficient to suppose that the walls of the right ventricle are endowed with the faculty of responding to a feebler stimulus than the walls of the left ventricle, for in all other muscles this faculty is quickened by arterial, and blunted by venous blood. On the other hand, it is easy to understand how the blood *in* the coats should cause simultaneous action, for it is distributed to both sides of the heart, through companion vessels, and at the same time. In this case

action must be caused on both sides simultaneously, if it is caused at all; and hence, the simultaneous action of both sides of the heart must be considered as an argument that the blood acts in the movements of the heart through the instrumentality of the vessels distributed in the coats, rather than by any influence exerted upon the lining membrane of the chambers.

There are several reasons why the blood should provoke the heart to rhythmical action, and yet not do this in other muscles, and these must be alluded to before leaving the subject. One is the more interjectional supply of blood to the heart. This happens, partly, from the immediate vicinity of the mouths of the coronary arteries to the orifice of the aorta; and, partly, from the presence of many openings (foramina thesbesii), through which the blood escapes, at once and directly, from the coronary capillaries into the chambers of the heart. Owing to the one cause, there are distinct pauses between the pulses of blood,—for in the heart there is no long arterial trunk to react upon the column of blood by its elasticity and convert an intermittent into a continuous stream, as is the case in all, or nearly all other muscles. Owing to the other cause, the blood is able to escape more readily from the heart than from other muscles, where in escaping it has to press before it a long column of venous blood. The heart, moreover, is supplied much more liberally with blood than any other muscle, and as the mobility of a muscle is in a direct ratio to its vascularity, it may be supposed that the heart dilates with each jet of blood into its coats because its muscle is suffi-

ciently dilatable, and that other muscle does not dilate under the same circumstances because it is not sufficiently dilatable. All this is both conceivable and probable: and the more so, as the muscles of the air-passages, which are amply supplied with blood, but less so than the heart, do exhibit rhythmical movements which are only less rapid than those of the heart.

2. The effects of physical agents upon the action of the heart, so far as can be determined, appear to be very similar to the effects of vital agents. Heat stimulates, the opposite of contraction. Harvey observed that the rhythmical movements of the heart in the snail and in some other invertebrate animals, were suspended in winter, or else repeated so slowly as to escape the attention of ordinary observers; and that the organ itself was so shrunk or contracted as to differ but little from the characters of a common vessel. Cold diminishes the size and suspends the beats of the heart which has just begun to labour in the vascular area of the chick, and heat restores the size and renews the beats. The effect of cold is so marked that under this influence the pulsating point disappears altogether and becomes merged in the surrounding vessels. All this may be readily seen by taking the heart of a chick of the third or fourth day, together with a portion of the vascular area surrounding it, and by placing them on a slip of glass. On doing this, the heart will stop and disappear, and reappear and beat until it is completely dried up, if the under surface of the slip be placed in alternate contact with cold and hot water. Nay more, the dried

heart will more than once resume its rhythm if it be moistened by warm water.

Cold and heat act similarly upon the heart of the frog. Cold stops the beats and warmth reanimates them, or, if they had not entirely ceased, it quickens them. Thus, in one of Weber's observations, a heart which was beating eight times in a minute was quickened to eighteen times by the warmth of the hand.

The heart, again, ceases to pulsate in an exhausted receiver, and its pulsations may be alternately renewed or arrested by alternately admitting or exhausting the air. It beats much more quickly in oxygen, and it immediately ceases to beat in hydrogen, or carbonic acid.

— When the heart beats after its removal from the body, the grand agents in the action appear to be air and warmth. If these be withheld the rhythm ceases, but not because contraction fails to be excited, for the heart becomes more and more contracted, and when the rhythm has entirely ceased, it is most contracted of all. Under these circumstances, indeed, the heart appears to be in the very same predicament as the air-tubes, and to go on dilating and contracting out of the body, for the very same reason that they go on dilating and contracting within the body. The air, that is to say, provokes dilatation by the stimulant properties of its oxygen, and thus finds its way through the cut ends of the vessels into the coats of the heart. There it remains until it has given up the oxygen required for the purposes of oxygenation, when the cause of dilatation being removed, the

organ returns to the contracted state. Fresh air effects an entrance in the same way, remains until it has lost its stimulant properties, and is then expelled as before: and so on, until the irritable fibres of the heart lose their capacity of dilatation, and fix in a state of contraction, which becomes more and more confirmed until at last it sets in cadaveric rigidity.

— In reference to the heart, therefore, the only conclusion is that the muscle contracts in absence of any stimulation, and because of that absence; and this being the case, the result harmonises with that which has been arrived at in the former chapters, and the general conclusion is, *that all stimulants, vital and physical, antagonize muscular contraction, and that contraction happens from ordinary molecular attraction when the muscle is not stimulated.*

Nor is it a matter of indifference whether muscle contracts because it is stimulated, or because it is not stimulated. If it contracts because it is stimulated, the phenomenon is peculiar to living bodies, and altogether unintelligible on any known physical principles. If, on the other hand, it contracts because it is *not* stimulated, or in other words, because some stimulus has been removed which had prevented the natural molecular attraction of the tissue from coming into play, then the phenomenon becomes analogous to the contraction which takes place in a bar of metal, or in any other inorganic body, on the abstraction of heat. In this case the result is to break

down another barrier between the organic and inorganic world, and to take another step in the demonstration of that universal law which philosophy divines, and to which the discoveries of science continually tend. In this case the result is to furnish a physical explanation of those three great and fundamental problems in physiology, which have ever been a source of perplexity to the physiologist—the contraction of muscle, the movements of the blood in vessels independently of the heart, and the action of the heart itself—and this by one and the same means.

Muscular contraction receives its physical explanation by being allied to the contraction which occurs in metals and other inorganic bodies on the abstraction of heat, for in becoming an effect of common molecular attraction, it becomes, in fact, an effect of the grand law of gravitation.

The movements of the blood in vessels independently of the heart receive their physical explanation in the way set forth in the second chapter. The vessels expand whenever they are stimulated, as they do when they are heated, and, expanding, they draw the blood into them, and, as in ordinary muscle, they contract in absence of stimulation.

The rhythm of the heart receives its physical explanation in the way pointed out in the last chapter. The state of expansion, or diastole, is still the result of stimulation ; the state of contraction, or systole, is still the same passive phenomenon which it is seen to be in ordinary muscle, and in the coats of vessels. The rhythm of the

auricles is *secondary* to that of the ventricles, and the rhythm of the latter organs is the natural consequence of certain physical causes. In relation to the blood (which is the prime cause), the systole induces the diastole *because* it forces a jet of blood through the coronary arteries into the coats of the heart, and the diastole induces the systole *because* it cuts off this jet for the time being; and in this way systole induces diastole, and diastole induces systole, as long as the heart and blood are at liberty to act and react. And so also in relation to other kinds of stimulation, for in every case the diastole is the active, and the systole the passive phenomenon, and the rhythm is as much the natural consequence of the relation existing between the agent and the heart, as it is when blood is the agent.

The doctrine, then, that all stimulants, vital and physical, antagonise muscular contraction, and that contraction happens from ordinary molecular attraction, when the muscle is not stimulated—which doctrine has gained in probability at each successive step of the inquiry—may be said to receive its final *physiological* confirmation in the physical explanation which it affords to the three great and fundamental problems in physiology—muscular contraction, the movements of the blood in vessels independently of the heart, and the rhythm of the heart. And hence the necessity for the full investigation of the law of muscular contraction before entering upon the investigation of epilepsy and of other disorders in which

muscular contraction is in excess, for if the old doctrine that muscular contraction is the result of stimulation must fall to the ground, then all pathological deductions founded upon that doctrine must fall along with it.

PART II.

EPILEPSY

AND OTHER

AFFECTIONS OF THE NERVOUS SYSTEM

WHICH ARE MARKED BY

TREMOR, CONVULSION, OR SPASM:

THEIR

PATHOLOGY AND TREATMENT.

EPILEPSY,

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TREMOR, CONVULSIONS, OR SPASM:

THEIR PATHOLOGY AND TREATMENT.

In the following pages the first chapter is devoted to the pathology of epilepsy, the second to the pathology of affections allied to epilepsy, the third to the question of periodicity, and the fourth and last to the treatment. Attention is paid, first of all, to epilepsy, because this is the great type, as well as the most frequent and important example, of all those disorders which are marked by excess of muscular contraction, and because it affords the clue to the explanation of all the rest.

CHAPTER I.

ON EPILEPSY.

Preliminary Considerations.

In lunatic asylums epileptics are classed and confounded with demented and imbecile patients. They are the most miserable of that miserable company. They

are wanting in vital heat, and for this reason they love to bask in the sun, to huddle around the fire, or to crouch in the neighbourhood of the pipes of hot water which serve to warm the cells and corridors. Their hands are cold and clammy, their complexion pale and sallow, their countenance languid and dejected, their pulse weak and miserable, their flesh flabby and often wasted, their little strength easily spent and when spent slowly recruited. Often, also, they exhibit signs of scrofula, of syphilis, and of mercurial abuse.

The mental are in strict conformity with the bodily characteristics. Sometimes, but very rarely, the mind may be endowed with a more than ordinary share of genius and talent, but in such cases the fits occur in the state of weariness and exhaustion following the periods of excitement, and not in these periods. Often the mind is bewildered and blighted with insanity, and then the fits alternate with the paroxysms, and coincide with the intervals of collapse. This, indeed, follows from the sequel, for while the fits become more and more severe and frequent as the malady progresses, the indications of genius and talent, and the delusions of insanity, become more and more feeble, until at last the condition is one of pitiful fatuity, from which no single ray of the divine principle beams forth. This picture is dark, but not darker than reality. Indeed this one fact —that epilepsy, without losing any of its convulsive character, invariably tends to merge in fatuity—is of itself sufficient to show that mental or bodily energy and activity form no part of the epileptic temperament.

The Paroxysm.

In order to a clear conception of the paroxysm, it is desirable to isolate the phenomena belonging to it from those which go before and follow after it.

(*a.*) Upon the eve of a fit, confirmed epileptics are noticed to sit or move about in a moping or listless manner, and to exhibit various indefinable indications of a decided lack of vital energy. They are silent and moody, or speak only to complain of creeping and chilly feelings, of troublesome shudderings, or of faintness and sickness. The countenance is rarely otherwise than pale and sad; often it is dusky, and bedewed with cold and clammy perspiration; and in very old cases there is an additional shade of dulness upon the expressionless and embruted features. The respiration is interrupted by frequent sighs; the pulse is weak, irregular, and slow. These symptoms are more decided when the malady is of long continuance, as in the majority of those cases which are found in the wards of lunatic asylums and workhouses; but they are always present in a greater or less degree.

(*b.*) The fit itself is very variable in its characters, and especially in the manner of its onset. In its slightest forms the patient pauses suddenly in the midst of anything he may happen to be doing or saying at the time, his countenance flushes or darkens, his expression is fixed and confused, the veins of the neck and temple are more clearly defined, and there are spasmodic twitchings in the neck and hands and elsewhere. After a moment

or two these symptoms pass off without leaving any reminiscence behind them, and thus the mental faculties are shown to have been suspended for the time. The fit, indeed, has been so slight and transitory, that it would have passed unnoticed if attention had not been accidentally directed to it by others.

In other and more ordinary cases, the fit is ushered in by a cry or scream, and the patient is at once dashed to the ground. Instead of a few passing starts in the hands and neck, the whole frame is seized with violent and frightful convulsions, the features are horridly drawn, the head is twisted to one side, the eyes are distorted and half protruded from their sockets, the teeth are gnashed together and the tongue is mangled between them until the mouth overflows with bloody foam, the limbs are violently dashed about, the chest is so fixed that all proper respiration is at an end, and last of all, the bladder and intestines and seminal vesicles participate in the spasm and expel their contents. The temperature of the skin is usually below the natural standard, and the hands and feet are cool or actually cold; but in the course of the paroxysm, and as the asphyxial symptoms gain ground, the head and neck become warm and tumid, the tumidity rapidly increases, and the colour changes from dull red to deep blue or black. In a less degree, also, this change extends to the rest of the body, but as a general rule the hands and feet remain cool and pale throughout, or only acquire a slight blueish or venous tinge. The pulse rapidly becomes insensible, or nearly so, though the heart beats with tumultuous

violence. There is no consciousness whatever, and the most violent stimulants fail to rouse the dormant senses.

In other cases, the fit is ushered in by signs which indicate the failure of the cardiac action; and here, though the convulsion may be every whit as violent, and consciousness and sensibility as completely paralysed, the countenance and neck remain pale, or at most livid, from beginning to end. Cases like these, which are by no means uncommon, are most generally to be met with in persons whose mental and bodily powers are completely broken down, as in those miserable people who are at the same time demented and epileptic.

(*c.*) For some time after the violence of the fit is over, the limbs are shaken by passing quivers, and the breathings interrupted by sobs or gasps, but at length these residuary troubles end in a state of comatose sleep, in which the breathing is often loud and stertorous. Then the lungs resume their natural action; and with this change, and consequent upon it, the veins of the head and neck become unloaded, the colour and pulse return, and the patient wakes to an obscure and troubled consciousness. Sometimes a bloodshot and ecchymosed state of the eyelids and of other parts of the countenance remains to testify to the violence of the former congestion. This recovery is usually slow and tedious, but not unfrequently the circulation rights itself in a few minutes, and the cheeks flush, and the carotids throb, almost as soon as the fit is over. The circulatory reaction is usually considerable.

The Pathology.

In order to arrive at the true pathology of epilepsy, it is necessary to begin by ascertaining the real state of the three great systems chiefly concerned—the vascular, the nervous, and the muscular—and then to proceed to examine the causes which induce the malady.

I.

1. Interrogating the *vascular system*, all the symptoms are found to offer a direct contrast to those symptoms of plethora which are met with in a butcher. The skin is pale and sallow, or dark and congested, as in cases of venous congestion, and never bright red or roseate. The pulse is feeble and wretched, and never full and resisting. There are, indeed, occasional flushes of brighter colour and of fuller pulse, which flushes come on when the patient is heated by warmth or excitement, but they pass off immediately under the influence of cold or of any other depressing agent. The circulation, indeed, is readily disturbed by causes of excitement or depression, and as a rule the depression is far below the healthy standard of activity, and the excitement scarcely up to that standard.

On the eve of the fit, if there be any change at all, the skin is paler and more congested, and the pulse feebler than usual.

In the fit itself the state of the circulation is virtually one of syncope or asphyxia,—in the one case the failure being dependent, in a great measure, upon inaction of the heart, in the other upon imperfect aëration of the blood. It is no proof of circulatory activity in the latter case that the head and neck become tumid and warm, for the rapid change in colour from dull red to blue or black, is a sufficient proof that the tumidity and warmth are due, not to injection of fresh blood into the arteries, but to retardation of blood in the veins. The silent pulse at the wrist is the proof of this. In either case, therefore, the circulation is very much depressed.

After the convulsion reaction sets in, and often with great rapidity, and the cheeks flush and the carotids throb, as in active cerebral determination, but this is *after the convulsion*, and during the consecutive stupor or coma. If the convulsion returns, the reaction vanishes, and again gives place to the contrary symptoms of syncope or asphyxia. This fact would have been better known, and its universality would have been admitted, if care had been taken to preserve the distinction which exists between the symptoms belonging to convulsion, and the symptoms belonging to coma.

Nor is the palpitation of the heart, or the throbbing which has been occasionally noticed in the neck during the height of the fit, any objection to this view. There is no doubt that the heart may palpitate violently, and yet propel little blood into the vesssls; and that it does so in the present instance, is proved by the state of the

pulse at the wrist. The throbbing in the neck, on the other hand, may be due to cardiac regurgitation, for at the time of its occurrence, the degree of asphyxia is so great that the right side of the heart may be supposed to be distended so as to separate the curtains of the tricuspid valve, and make ventricle, auricle, and vein one common cavity; or it may be due—as suggested by my brother—to a convulsive action in the coats of the vessels, similar to that which has seized upon the bladder, intestines, and seminal vesicles. Under any circumstances, it cannot be due to increased arterial injection, for the state of the pulse at the wrist, and the prevailing asphyxia, render such an idea unsupposable.

It would appear, therefore, that during the fit the circulatory powers are depressed in an extreme degree, and that in the very height of the paroxysm there is no proper circulation at all. The immediate cause of this change, so far as can be gathered from the history of the fit, is either failure of the heart's action, or interruption of the respiration—most generally the last; but what is the immediate cause of the interruption of the respiration is not easy to say. In the majority of cases, it would appear to be owing to spasm of the walls of the chest and of the diaphragm, rather than to spasm of the glottis, and the late experiments in tracheotomy upon epileptics do not disprove this idea. It appears so because it is very questionable whether the larynx can be closed by spasm except in very young children, and because epileptics do not exhibit the hooping inspiration which ought to follow the relaxation of the laryn-

geal spasm. The suffocative aphony—ὡς ἐν πνιγὶ ἀφωνίη,* is no proof of such spasm, for the want of breath which produces this aphony might be caused by immobility of the walls of the chest as well as by strangulation. After the fit, indeed, there may be a partial paralytic closure of the larynx, such as there is in some cases of apoplexy, but this is a different matter.

Be this as it may, however, there is no doubt that the state of the circulation during the height of the fit is one of prostration verging upon actual extinction. This is the first fact in the pathology of epilepsy.

2. Interrogating the *nervous system*, all the facts declare the same want of proper activity.

The signs of this want in the *brain* are very unmistakeable. The intellectual and memorial faculties fail day by day under the blight which eventually obliterates them. On the eve of the fit the patient is rarely otherwise than silent, sad, moody and still; in the fit he is bereft of all sensibility, consciousness, and volition; and for some time afterwards he is stupid, confused, and exhausted.

The fact, however, that epilepsy is so frequently connected with insanity—so frequently that out of 339 epileptics whose history was analysed by Esquirol, 269, or four fifths, were also insane—may be thought to furnish an objection to the idea that the mental state in this complaint is one of depression and eclipse, but this is not so in reality. Thus, out of these 269 cases, the greater part were demented,—were people, that is to say,

* Aretæus: 'De causis et signis morb. acutorum,' lib. i. c. 5.

whose real mental state is the negation of anything active. Nor is it really different with those epileptic maniacs whose derangement has a more active complexion, for in these cases it invariably happens that the epileptic and maniacal paroxysms are utterly uncongenial, and that the convulsions occur in the intervals between the periods of mental excitement, and never in those periods,—occur, in point of fact, in those times of depression which receive the first shadows of that total eclipse which happens in the end. This law is without exception.

The morbid appearances after death, though somewhat obscure, are to the same effect. In fatal cases the brain has been found to be congested, but this appearance is clearly owing to the manner of death, and it is admitted to be so. In other cases, various signs of chronic inflammation in the brain and its membranes have been met with, but these are clearly referable to insanity, and this for no other reason than that they are more common, or as common, in insanity without epilepsy, as in insanity with epilepsy. In other cases, there are signs of degeneracy and want of tone,—such as pallor, atrophy, softening, and dropsical effusions. Now these signs are common to dementia and fatuity, and this very fact furnishes a strong argument that they also belong to epilepsy. It does this because epilepsy invariably tends to terminate in, and to become confounded with, dementia. It does this because dementia is intimately allied with other convulsive diseases: indeed if a demented person is not epileptic, he is

almost sure to be afflicted with palsied shakings, or cramps, or spasms in one form or other.

Another appearance, which is almost constantly present in the heads of epileptics, and which would seem to have a similar significance to the rest, is the great preponderance of bony matter. The skull is much thicker and heavier than usual, and its thickness and heaviness are almost in direct relation to the duration of the disease. The several internal projections, as the clinoid processes, are considerably developed; there are osseous plates in the dura mater, and the falciform process, in particular, is more or less converted into bone. Now this increased tendency to ossification *may* be held to signify a tendency to degradation, rather than to development, in the parts about the head, for bone holds the lowest grade among the tissues; and in this way, the excess of bone becomes the proof of mental and vital depression. Under any circumstances, the contrary position cannot be held with any show of reason, and least of all can it be maintained that bony prominences excite the fit by exciting irritation or inflammation in the brain, for the symptoms during life, and the appearances after death, are quite opposed to such hypothesis.

The last argument, however, that the state of the brain is one of inactivity is derived from the condition of the circulation. No other state is indeed possible with this condition, which, as has been described, is one verging upon syncope or asphyxia. There is also an experiment by Sir Astley Cooper which throws a strong

light upon the condition of the cerebral circulation during convulsion, and which is itself rendered intelligible by the premises. "I tied," writes the baronet, "the carotid arteries of a rabbit. Respiration was somewhat quickened, and the heart's action increased; but no other effect was produced. In five minutes, the vertebral arteries were compressed by the thumbs; the trachea being completely excluded. Respiration almost directly stopped: convulsive struggles succeeded; the animal lost its consciousness, and appeared dead. The pressure was removed; and it recovered, with a convulsive inspiration. It laid upon its side, making violent convulsive efforts; breathed laboriously; and its heart beat rapidly. In two hours it had recovered; but its respiration was laborious. The vertebrals were compressed a second time. Respiration stopped: then succeeded convulsive struggles, loss of motion, and apparent death. When let loose, its natural functions returned, with a loud inspiration, and with breathing excessively laboured. In four hours, it was moving about, and ate some greens. In five hours, the vertebral arteries were compressed a third time, and with the same effect. In seven hours, it was cleaning its face with its paws. In nine hours, the vertebral arteries were compressed for the fourth time; and with the same effect upon its respiration. After thirteen hours, it was lively. In twenty-four hours, the vertebral arteries were compressed for the fifth time, and the result was the same; namely, suspended respiration, convulsions, loss of motion and consciousness. On the removal of pressure, violent and laborious respirations ensued; and, afterwards,

the breathing became very quick. After forty-eight hours, for the sixth time, the compression was applied, with the same effect."*

Arguing from the state of the pulse and the respiration in epilepsy it would appear that the *medulla oblongata*, the *spinal cord*, and the *sympathetic ganglia* are in the same condition of inactivity as the brain. Nay, it cannot be otherwise, for the functional energy of these organs, as of the system generally, must be in direct relation to the activity of the circulatory and respiratory changes. It is to be observed, also, that that remarkable want of muscular tone, which is a very marked peculiarity of the epileptic, is indicative of the want of energy in the spinal cord, if it be a function of this organ to supply this tone.

— It would thus appear that the system is completely *unnerved* in epilepsy, and this is the second great fact in the pathology of this disorder.

3. Interrogating the *muscular system* its condition is found to agree with that of the vascular and nervous systems. This is seen in the remarkable inadequacy to exertion, and in the slowness with which the system rallies after fatigue, as well as in the pallid and soft condition of the muscles on dissection, which condition contrasts very strongly with the normal redness and consistency of these organs. This is the third great fact in the pathology of epilepsy.

— Viewed in this manner, the vascular and nervous systems of the epileptic, as well as the mobile struc-

* 'Some Experiments and Observations on tying the Carotid and Vertebral Arteries,' &c., 'Guy's Hospital Reports,' No. 3, p. 465, Sept., 1836.

tures in which the convulsive phenomena are manifested, are seen to present unequivocal evidences of inactivity, and this inactivity—so far at least as the vascular and nervous systems are concerned—is found to be most marked in the fit itself.

II.

With respect to the causes, or supposed causes, which operate in the induction of epilepsy, it only remains to add that they are in accordance with the foregoing considerations. Thus: the seizure is referable, not to joy, but to fright and fear,—not to any natural excitement, but to the exhaustion consequent upon excess and abuse, —not to good cheer, but to hunger and privation. It happens at night, when the vivifying influence of the sun is withdrawn, rather than in the day. Much obscurity hangs over these matters, from the careless manner in which the most incongruous agencies have been grouped together as exercising the same influence upon the system, and much obscurity is inevitable from the difficulty of untying the complex knot which holds together the several influences acting upon the body; but there is no reason to doubt, and every reason to believe, that these several causes of the fit, are of an exhausting, and not of an exciting character.

On a review of these facts and considerations it is sufficiently evident that epilepsy cannot be caused by any excitement of the muscles consequent upon the ex-

cessive supply of nervous or any other stimulus. On the contrary, everything is in harmony with the physiological premises, and—as might be anticipated from these premises—the convulsion would seem to depend upon *want* of vital stimulation, which want had allowed the molecular attraction of the muscles to come into play and gain the ascendancy.

CHAPTER II.

ON AFFECTIONS ALLIED TO EPILEPSY.

These affections admit of being divided into three categories—the tremulous, the convulsive, and the spasmodic, but it must not be forgotten that such division is purely arbitrary, and that spasm, convulsion, and tremor are continually occurring in the same case, and often at the same time.

The first category includes the tremors of delicate and aged people, chorea, paralysis agitans, delirium tremens, the rigor and subsultus of fever, and the tremor of mercurial poisoning.

The second category may be subdivided into three sections, according as the convulsion is dependent upon general disorder, upon local disorder, or upon death. In the first section, are the convulsions of fever, of hydrophobia, of saturnine and hydrocyanic acid poisoning, and those dependent upon retention of urea in the blood. In the second section, are the convulsions of cerebral disorder, of uterine disorder, and of intestinal disorder. In the third section are the convulsions of death.

The third category includes laryngeal spasm, cholera-cramps, tetanus, ergotism, catalepsy, and rigor mortis.

Preliminary Considerations.

Upon the outset of this enquiry several obvious and admitted facts suggest themselves to the mind as harmonizing with the previous conclusions respecting epilepsy.

1. The subjects of nervous trembling have a certain delicacy of constitution which cannot be overlooked, and if not women, they have the feminine habit of body in a very marked degree. Those who tremble from old age or from shaking palsy present unequivocal marks of decrepitude and decay—the listless wish, the snowy or hairless head, the fireless countenance, the wasted limb, the feeble pulse. Chorea is almost peculiar to females, and to females whose parents were infirm or aged, or who themselves have become enfeebled by improper or injudicious habits. It often originates during some severe and exhausting disease, and is always accompanied by signs of debility. The atony of the circulation is usually indicated by paleness of the lips, face, and tongue, by pastiness of the skin, by effusion into the serous cavities, and by rheumatic deposits.

2. Convulsion happens most frequently in women and children, and but rarely in men, and this fact is an argument that other convulsive disorders besides epilepsy are connected with a state which is characterised by weakness rather than by strength.

3. Spasm, again, occurs more frequently in women than in men, and most frequently in the more irritable and weakly of women. Cramp is the constant companion

of tremulousness. It increases with the advances of age, and is almost permanent when nervous tremors become intensified into palsied tremors. The subjects of catalepsy, in like manner, are more delicate and impressible than they ought to be. Their skin is usually pale or dingy, their pulse readily disturbed, their general appearance either hysterical or apathetic. A cataleptic boy, a patient of my own, was as irritable, uncertain, and fretful as an infant. His apprehension was slow, his memory weak, his head large, his eyes staring, his pupils dilated and sluggish, his complexion sallow and venous, his hand cold and clammy, his pulse slow and feeble, and lastly, the state in rigor mortis is expressed by the name.

The Paroxysm.

I. *In affections belonging to the first category.*

1. The tremors of debility and old age are too well known to require any description, and so is the *unmanned* condition of the system in which they occur.

2. Chorea consists in certain tremulous movements, and in certain irregular and often comical convulsive startings, either of the whole body or of part of it—often of a single side. The muscles, as it were, are disobedient to the will, for the disturbance is always greater when they are called upon to make any voluntary effort. They are also disobedient to that power which coordinates the action of several muscles in a common purpose, and hence such acts as handling, standing, walking, or speaking, are either ill performed or altogether impracticable. Sometimes the will is weak, and

this power of coordination retained, and the person thus circumstanced may be constrained to twirl about on his heels, to rush backward or forward, or to execute dancing movements such as were exhibited, in ancient times, in the dance of St. Vitus and St. John, and perhaps also in the tarantula dance; and, in modern times, in the leaping ague of Scotch writers, and in the jumpings of certain wild religionists. Ordinarily, the face is affected first; then the limbs; and last of all the trunk. The disturbance may vary from a slight tremulous twitching of the features to a convulsive agitation of such severity that the patient cannot be kept in bed. The skin is usually cool and pale, particularly in the hands and feet. The pulse fluctuates a good deal; but it is always weaker than it ought to be, and weakest during the height of the paroxysm. The respiration is not sensibly affected. There is more or less wasting in the muscles, and when the disorder is confined to one side—a limitation which, according to Wicke, occurred in 58 cases out of 149*—the wasting is on the affected side. The power of fixing the attention is very imperfect, and in extreme or old cases there are obvious indications of imbecility. There is neither pain nor sense of fatigue; and the sleep is usually unaffected, except in very bad cases. The muscular disturbance is generally quietened during sleep.

3. In paralysis agitans the occasional and partial tremors of old age have become constant and universal,

* Dr. Romberg's 'Manual of Nervous Diseases,' ed. by Dr. Sieveking, vol. ii, p. 56.

and in very extreme cases they do not cease during sleep. If walking is at all practicable, it is performed by stepping hastily and tremblingly on the toes and fore part of the foot. The head, also, and body are so bowed forward that there is a constant danger of falling on the face. Last of all, the hands, feet, and tongue fail in their proper offices, the nether outlets of the body are uncontrolled by the will, and the patient has to be fed and treated as a child.

4. The trembling of delirium tremens, which is only the aggravated form of that trembling from which drunkards habitually suffer when sober, is principally confined to the hands and limbs. It is associated with extreme fidgetiness and restlessness, and more rarely with convulsive startings. The accompanying phenomena are very marked. The hands and feet are cold, the pulse is quick and weak, the respiration is disturbed by sighs, the tongue is moist and creamy, and every exertion is attended by profuse perspiration. The mind is confused, irritable, despondent, anxious, and tortured with gloomy forebodings or spectral delusions. Everything and everybody is an object of mistrust or fear or dread. Sleep has vanished, but there is no headache. There are occasional fits of unruliness, and sometimes of fierceness, but these are easily subdued by ordinary firmness on the part of the friends and attendants. As the malady progresses, the tremors take the character of subsultus, and convulsive startings become more common, the coldness of the hands and feet extends to the rest of the limbs, or even to the

trunk and head, the skin is still drenched in perspiration, the delirium becomes low and muttering, and last of all, mortal collapse and death supervene. These symptoms not unfrequently change into, or alternate with, those belonging to inflammation of the brain, in which case the skin becomes dry, headache and other symptoms of fever make their appearance, *and the tremor ceases.*

5. The tremor of fever and the accompaniments of that tremor are familiar to all. The rigors or shudderings which occur at the commencement and which are described by their name, are accompanied by chilliness and paleness of the skin, blueness of the nails and *cutis anserina*, by feebleness and frequency of the pulse, by sickness or vomiting, by indescribable feelings of languor, feebleness, and oppression, and by aching pains in the head, back, and loins. The subsultus or muscular twitching which marks the termination of the malady is attended by a dusky and cool skin, a fluttering pulse, a silent and fainting heart, a short and sighing respiration, and by every other sign of mental and bodily exhaustion and prostration.

6. The tremors of slow mercurial poisoning are very like those of chorea, and the attendant symptoms are similar. The muscles are equally disobedient to the will, and all coordinated movements are equally defective. The skin is grey and dry, the pulse weak and subject to great fluctuations from very trivial causes, the appetite capricious or wanting, and all mental and bodily strength greatly impaired. The end of the unchecked disorder is in paralysis and premature old age.

II. *In affections belonging to the second category.*

The general features of convulsion vary considerably, and so do the attendant circumstances, and this will be best seen by considering them under the heads which have been already indicated.

(*a.*) Convulsion arising in general disturbance.

1. The convulsion connected with fever arises at two distinct times,—at the onset and at the end of the disorder. In the latter case it is in reality the accompaniment of death, and as such it will be considered in the proper place: in the former case, it is, as pointed out by Dr. Copland, the substitute of rigor. The convulsion of the beginning of fever is common in children, particularly in connexion with smallpox, and it is as uncommon in adults. It is usually violent and epileptiform in its characters. The attack is ushered in by twitchings in the muscles of the face, by cramps in the feet and hands, and by occasional shocks and shudderings of the entire body. It is accompanied by squinting and rolling of the eyes, by gnashing or clenching of the teeth, by violent backward and sideward tossings of the head, by flexure of the fingers and toes upon the palms and soles, by twisting inwardly of the wrists and ankles, and by violent and rapid bendings and extensions of the limbs, by rigidity of the muscles of the chest, and, in extreme cases, by expulsive contractions of the bladder and intestine. Usually, the respiration is quite suffocative, and the sounds proceeding from the windpipe are sonorous and hissing, as if the patient

was being strangled. The scalp and the integuments of the head and neck rapidly become warm and tumid, the eyes bloodshot and the veins gorged, and, as the fit continues and the asphyxial symptoms become more urgent, the tumidity increases until the features are frightfully distorted and distended, and the colour rapidly changes from dull red to venous blackness. At the same time the surface of the limbs, and of the body generally, is pale and cold, or else livid and cold. Sometimes, the accompaniments of the fit are of a syncopal rather than of an asphyxial character, and the face and neck remain pale and collapsed throughout. The pulse is always very feeble, and—if it can be felt at all—very quick; but usually it is imperceptible in the limbs during the height of the paroxysm. The intelligent and sentient faculties are completely suspended, and this suspension continues for some time after the paroxysm is at an end.

2. The convulsion of hydrophobia occurs in paroxysms, the paroxysms increasing in violence and the intervals decreasing in duration as the disease progresses. The convulsion begins in suffocative and strangulatory spasms of the muscles of respiration and deglutition; then it extends to the limbs and trunk; and last of all, to the bladder and intestine. Sometimes, but not usually, the convulsions are of a tetanoid character. In the intervals there is the greatest inquietude and restlessness, and every voluntary movement is hurried, impulsive, and almost convulsive. Often there is constant tremor and tremulous agitation. The hands and feet are cool or cold, and so is the surface generally, though in

a less marked degree. The pulse is quick and feeble, and the respiration quickened and often interrupted by sobs and sighs. The mental state is one of fear or despair, with occasional outbursts of delirious violence, in which there is a tendency to injure, and sometimes to bite others. There is more or less pain in the wound and cicatrix, and in the neck, and in the pit of the stomach, and what is more intolerable than ordinary pain, there is a distressing sense of suffocation as from some impediment in the throat. The most marked and distressing symptom, however, is the excessive irritability of the whole body, and the extreme readiness with which a paroxysm is induced by any ordinary impression upon the senses. A gust of air, a bright light, a sudden sound, a rough touch, have all this effect. The gullet is similarly sensitive, and because drinking, or any attempt to swallow, provokes the paroxysm, the patient dreads to drink, though he does not fear the water as the name of the disease implies. All the secretions appear natural, except the saliva, which is viscid and abundant. This proves to be a source of great distress to the patient, for it cannot be swallowed or expectorated without great difficulty, nor can it be rinsed away, for the contact of the water with the throat provokes the spasm. Still there is a constant wish to do so, and this feeling appears to be concerned in causing that hankering after water which is usually witnessed.

3. The convulsion occasionally associated with chronic lead poisoning appears to be very similar to epilepsy. The symptoms are the same, or if there is any difference

it is only in the greater violence and continuance of the paroxysm and of the subsequent stupor.

4. The convulsion caused by poisoning with hydrocyanic acid is general and violent, and the more prominent concomitant symptoms are paleness, coldness, failure of the pulse, and insensibility.

5. The convulsion consequent upon the retention of urea in the blood is also general and violent, but without any special character. It is either the immediate precursor of, or the actual attendant upon, death, and its more prominent accompaniments are cold and clammy extremities, hippocratic countenance, fluttering pulse, cadaverous odour, hiccup, absolute insensibility and unconsciousness, together with that disposition to slip down to the foot of the bed which is the consequence of extreme muscular prostration.

(*b.*) Convulsion arising in local disturbance.

1. The convulsion connected with cerebral determination and congestion may be partial or general, but it is usually general, and of the character described when speaking of the convulsion connected with fever. It arises in that variety of cerebral determination or congestion which originates in debility and inanition, and which is without fever or excitement from the commencement, or else in the other and sthenic variety of the disorder *after* the primary stage of fever and excitement has subsided. In either case the immediate antecedents and the actual concomitants of the fit are the same. The face is cool and sunken, and the hands and feet are clammy

and cold. There is frequent gaping and sighing, and occasional sickness and vomiting. The pulse is weak and often slow, but it fluctuates remarkably, and is greatly increased in frequency under any bodily or mental exertion, when also the heart palpitates considerably. There is a sense of weight and fulness, and of rushing and throbbing in the head, and the patient is apathetic, dejected, languid, oppressed, stupefied, and forgetful. Headache may or may not be present: if it is, it is mainly in the course of the great sinuses at the back of the head; and if it is not relieved, it is not aggravated, by the recumbent posture. The vision is dim, the hearing dull, the speech slow or hesitating. In the fit the pulse fails, and there are general signs of syncope; or the respiration fails, and there are symptoms of asphyxia, the pulse failing secondarily: and in every case the functions of the brain, lungs, and heart are suspended, or nearly so. Afterwards reaction sets in with considerable rapidity, and the symptoms change to those of active determination to the head, but not until the convulsion is over.

The convulsion connected with inflammation of the brain or its membranes has a very similar history. If it does not occur in the primary stage of depression, in place of rigor, it occurs *after* the end of the true inflammatory stage. Feverish flushes of heat and redness have ceased to pass over the head, the limbs have become cool and chilly except means be taken to preserve and supply warmth by artificial means, the pulse beats with great rapidity if the patient attempts to exert himself in

any way, the breathing is hurried and irregular, the iris oscillates on the point of becoming permanently dilated, delirium has lapsed into drowsiness, and pain is absent or blunted. When the convulsion makes its appearance, it is in company with symptoms of syncope or asphyxia —usually of asphyxia, in which case the head and face become gorged and black from the retention of blood in the veins. The only difference between inflammation of the brain and inflammation of the membranes of the brain, so far as the convulsion is concerned, is that the convulsion supervenes at an earlier period in the former affection in consequence of the shortness or absence of the stage of excitement and fever.

The convulsion occasionally connected with apoplexy may be at the beginning or end of the fit. It may be partial or general, but it is most frequently partial. If it occurs at the commencement, it is in those forms of apoplexy which have been preceded by symptoms of passive cerebral congestion, and in which the insensible and unconscious body is found to be cold and pale and comparatively pulseless. If it occurs at the end of the fit, all true vascular excitement has passed off, and the system is well nigh asphyxiated by that partial closure of the glottis which is due to paralysis of the parts.

The convulsion connected with inflammation of the spinal cord or its investments is distinguished for the most part by tetanoid rigidity of the muscles, which rigidity begins in the jaws and neck, and extends thence to the back and limbs. There is no fever. The skin is cool and perspiring, the pulse rapid and feeble, the

breathing laboured and hurried, particularly if the dorsal region of the marrow be the part affected. There is usually pain in the spine on percussion or on the application of a hot sponge, and there are pains or tingling or other abnormal sensations around the body in the zone corresponding to, or in the course of the nerves radiating from, the affected part. The intelligence is unaffected if the brain be not implicated. If the substance of the cord be inflamed the common result is paralysis and loss of sensibility, not convulsion and pain, the paralysis usually beginning in the chest, and extending thence to the legs.

2. The convulsion of hysteria is usually ushered in by an attack of fainting, by a copious discharge of pale urine, by much flatulent disturbance in the bowels, and by the feeling known under the name of *globus hystericus*. Then the patient begins to scream, and to toss the head and limbs about violently, the tossings being much greater than those which occur in epilepsy and in the more violent kinds of convulsion, and the muscular rigidity much less. The countenance is pale, and the hands and feet cold. The pulse is very feeble, and the respiration attended with sighs. The pulse, also, fluctuates considerably, and it is easily depressed or excited by very inadequate causes. The eyes are wild and rolling, but not bloodshot. The consciousness and sensibility are never completely suspended, and there is no sleep or dulness afterwards, the recovery from the fit being almost instantaneous.

The convulsion of childbirth is of two kinds,—the one

depending more especially upon hæmorrhage, the other upon nervous exhaustion. The convulsion which occurs in the last two months of pregnancy or in the fortnight after delivery, and which also has the name of puerperal, has no sufficient title to be considered as distinct, in the one case, from hysteria or epilepsy, and in the other case, from the convulsion occurring in poisoned states of the blood, as in smallpox and some other fevers.

The convulsion of flooding is distinguished by frequently repeated or continuous shudderings, succussions and shocks, by constant tossings of the head and limbs, and by occasional and transient attacks of muscular rigidity. The disturbance is general. Even the lips and tongue are blanched and cold. The pulse is rapid, fluttering, or imperceptible, and the breathing a continued sigh or gasp. Some little consciousness is retained except when the patient faints outright.

The convulsion dependent upon the exhaustion of a prolonged or difficult labour differs in many respects from that which has just been described. The paroxysm is very violent and general, and the tongue is often bitten as in epilepsy. The respiration is almost or altogether suspended, and the sounds given out from the throat are like those of a person who is being strangled. The head and face become tumid and black. During the paroxysm the pulse is either quick and weak, or altogether imperceptible, particularly in the limbs; but afterwards it rallies with great rapidity, and considerable reaction may ensue. Sometimes, but not very

frequently, the accompaniments of the fit are syncopal rather than asphyxial in their character, and in this case there may be little or no reaction. Usually many paroxysms occur in succession, and the consciousness, which is completely suspended during the fits, is not recovered in the intervals.

3. The convulsion so frequently connected with dentition and worms, or with other and analogous disturbance in the alimentary canal, begins with various twitchings in the face, with startings and stretchings in the limbs, and particularly with spasmodic contractions of the hands and feet, and of the wrists and ankles. The fit itself, in its worst and most general forms, is attended by squinting and by clenching of the jaws. The concomitant symptoms are sometimes asphyxial and sometimes syncopal in their character, but more usually asphyxial; and in either case, the pulse is imperceptible or nearly so, and the mental faculties are completely abolished.

(*c.*) Convulsion connected with death.

The convulsion which makes its appearance under these circumstances varies in its character and accompaniments according as the mode of death is syncopal or asphyxial. It varies somewhat, also, when comatose symptoms are present, but this variation may be overlooked, for so far as concerns the convulsion, the immediate concomitants may be related either to syncope or asphyxia.

The convulsion associated with mortal hæmorrhage

is marked, first, by restlessness, agitation, and incessant tossings, and then, by sudden convulsive shocks of the limbs and trunk, with little or scarcely any fixed rigidity of the muscles. All this while the pulse and heart are fluttering in their last throes, the forehead is bathed in cold sweat, the hand is corpse-like, the eyes are fixed, the pupils dilated, and the mind and senses benumbed already by mortal sleep.

The convulsion associated with mortal asphyxia is more violent and continued, and the muscular rigidity is very considerable. The concomitant symptoms are those of asphyxia—the "face black and full of blood," the eye-balls starting and staring, the nostrils stretched, the wrist pulseless, the brain stupefied.

After death the body usually remains still and flaccid until the occurrence of cadaveric rigidity; but now and then it begins to move in slow convulsions after the complete cessation of the action of the heart and lungs, and goes on moving in this manner for some time. These slow convulsions have been noticed by several observers, but chiefly by the late Mr. Barlow of the Westminster Hospital, who indeed made them the subject of especial investigation during the cholera-epidemic of 1848. They have been seen in persons who have died of yellow-fever, of tetanus, and of apoplexy, but chiefly in those who have died of cholera. They vary greatly in different cases. Sometimes the phenomena have been confined to mere tremulous twitchings of the features; sometimes the mouth and eyelids have gone on opening and shutting, or the limbs have been moved backwards or forwards;

and once the body was turned in bed. It is easy to understand, therefore, how such movements should have given rise to the idea that the corpse was returning to life, or that it had been abandoned before life was extinct, for on seeing a corpse move, or on finding it in a different position to that in which it had been left, it requires a philosophical effort, even on the part of the medical man, to get rid of this revolting idea.

III. *In affections belonging to the third category.*

1. The spasm of laryngismus stridulus occurs suddenly and without any premonition. It may be by itself; it may be associated with cramps in the hands and feet, or with general convulsions; or it may alternate with these cramps and convulsions. So long as it lasts the spasm causes an agony of suffocation; when it is over the air finds admission to the lungs with a crowing sound, and the patient is relieved. There is no cough, no pain, no alteration of voice, no fever, and in these negative features the affection differs mainly from the spasm of spasmodic croup.

The analogous spasm in hooping cough is very marked in its history. The disease in which it arises has two stages—the catarrhal and the convulsive. The first of these is attended by all the symptoms of coryza or catarrh, the cough being more sonorous and violent than usual, but *without any hoop*. The second stage is marked by the subsidence of all febrile symptoms, and by the supervention of the hoop. The hoop, moreover, disappears if

pneumonia or bronchitis be developed after its establishment, and remains in abeyance as long as the inflammation continues. In the paroxysm itself the general condition is more or less that of asphyxia.

2. The spasm of cholera begins in the alimentary canal, and extends successively to the abdomen, thighs, legs, chest, arms, and hands; and once established, it continues with little or no intermission so long as the disease continues. The surface of the body is cold, clammy, and blue. The pulse rapidly becomes imperceptible. The respiration is laboured and panting, and the breath cold. The sense of pain and suffering is greatly blunted, for the mental energies have succumbed to the blow which has prostrated the bodily powers.

3. The spasm of tetanus begins in the muscles of the face, and gives to the features a drawn and aged expression; then it lays hold upon the muscles of the neck, jaws, and throat, and causes great difficulty in moving the head, in opening the jaws, and in swallowing; and lastly it extends to the limbs, to the trunk, and even to the interior of the body. In the height of the disorder the eyeballs are firmly fixed, and the tongue is stiff and immoveable. Sometimes all muscles are affected equally; sometimes certain groups more than others, in which case the jaws may be locked and the rest of the body free, or the body may be bent backwards, forwards, or sideways, as the case may be. The spasms occur in paroxysms, without any perfect remissions, except occasionally during sleep. The surface of the body is at first of the natural heat and colour, but as the malady progresses it becomes cold, pale,

and perspiring. The countenance, from the very beginning, is pale and jaded, the paleness being overcast by occasional shadows of blueness when any unusual impediment is opposed to the proper aëration of the blood. The respiration becomes more and more laboured in proportion as the spasm gripes more and more firmly upon the muscles concerned in the process, until at last the struggle is agonising. The pulse, which is never more frequent or excited than natural, soon becomes feeble and frequent in the extreme. The sensitiveness and irritability of the system is greatly increased, and ordinary impressions on the senses are sufficient to bring on a paroxysm. The patient suffers excruciating pain in the cramped parts, at the pit of the stomach, and in the wound or cicatrix if the disease has arisen from such a cause, and he has a torturing sense of want of breath. Sometimes, but very rarely, there is no pain. The spasms are quiet during sleep, but sleep is usually absent. There is no stupor, except towards the end, and then, generally, from the circulation of imperfectly aërated blood in the brain.

The tetanus which is caused by poisoning with strychnia does not differ from the idiopathic disorder.

Common cramp—which may be looked upon as a local and transient manifestation of tetanus—agrees with the history of that disorder, in that the system is depressed, and the circulation languid, particularly in the cramped parts.

4. The spasm of ergotism, according to Romberg, who describes it from the accounts supplied by Wichmann, Taube, and Wagner, occurs in the following

manner. "The feet and hands are attacked with cramps in the flexor muscles. The fingers of both hands are bent like hooks, the thumb being pushed under the fore and middle finger in an oblique direction; the wrist is strongly curved inwards, so that the hand assumes the shape of an eagle's beak. The toes are also doubled under the sole of the foot. The spasm extends over the fore and upper arm, which are bent one upon another at an acute angle; it also extends over the thigh and legs, and over the back of the neck and the jaws."* These symptoms end either in trismus and tetanus, or in general convulsions of an epileptic character. The skin is dull and dry, except during the paroxysm, when it is perspiring. The pulse and respiration are affected in the same way as in tetanus. The several senses are more or less impaired, and that of feeling so much so, that in the end it may be said to be altogether abolished. This impairment is most marked in the limbs, but it extends also to the face and tongue. The spasms are accompanied by a pain which is usually relieved by extending the cramped parts. The intelligence is slow, but there is no positive stupor. The end of the unchecked malady is in paralysis and fatuity.

5. The spasm of catalepsy is of a different and milder kind. The voluntary muscles become rigid and slightly contracted, and the patient retains the expression of countenance and the posture which he had before the seizure. The muscles are pliable, and they remain in any position in which they may be placed. The appear-

* Op. cit., vol. ii, p. 45.

ance is very like that of a corpse, and the heart and lungs, and brain are almost as motionless as in a corpse. Sometimes the muscular rigidity is less marked, and the mental and bodily functions are less inactive, and in these cases the face and head are less pale and cool than the rest of the body, and the pupils are less dilated and disobedient to light. Sometimes, there is more activity in the circulation than in the respiration, and in this case there are signs of embarrassed breathing and of stagnant blood in the veins about the head and neck.

6. Rigor mortis begins in the neck and jaws, and then extends to the trunk and limbs, the flexor muscles, as a rule, being more contracted than the extensors. It does not pass by paralytic muscles, provided there be any relics of true muscular structure in them. It occurs soonest in persons whose vital powers are undeveloped or worn out, as in very early or very advanced age, and in those cases of prolonged disease where the powers of life have been completely sapped and destroyed before death, as in consumption. In these cases only a few minutes may elapse before its appearance. It is deferred, on the other hand, and often for days, in cases where death has occurred suddenly in the full glow of life.* Rigor mortis ends in decomposition.

The Pathology.

In order to arrive at the knowledge of the several affections allied to epilepsy, it is desirable to follow the

* 'Carpenter's Principles of Human Physiology,' 3d edit., p. 448.

path which was pursued in the investigation of epilepsy, and to consider, first of all, the condition of the vascular, nervous, and muscular systems, and then to determine the nature of what may be called the efficient causes.

I.

The condition of the *vascular system* is pretty fully set forth in the accounts of the paroxysms, but in order to obtain a clear and connected idea concerning it, it is necessary to resume the question, even at the expense of some repetition.

1. There can be no doubt that the circulation is greatly depressed during an attack of trembling, and that a flushed face or a bounding pulse are never present at this time.

The circulation in chorea is subject to great fluctuations of excitement and depression under circumstances which would exercise little or no influence upon a strong individual, but any excitement is but slight and fugitive when compared with the opposite state of depression. The pulse, almost without exception, is small and slow, and it is invariably so during a paroxysm. As bearing upon, and illustrating this state of things, it is also to be remembered that very frequently the symptoms of chorea manifest themselves for the first time after the institution of a vigorous antiphlogistic treatment, and that they are suspended by the accidental occurrence of any inflammatory affection.

The paleness and chilliness, and the decided relief afforded by wine, reveal the real state of the circulation in paralysis agitans.

In delirium tremens the perspiring skin, the cold hand, the quick and compressible or fluttering pulse, and the treatment demanded are all significant and unmistakeable facts. These symptoms are also the true concomitants of the trembling, for if the dry skin, and thirst, and hard pulse of true cerebral inflammation make their appearance, the tremor invariably disappears *pari passu* with that appearance. The opposite change of tremor into subsultus and convulsion, which takes place as the heart and pulse fail in the course of the disorder, is another argument to the same effect.

Rigor is coincident with a sense of coldness, a feeble pulse, a sunken countenance, a corrugated skin; and subsultus, with a circulation faltering on the very verge of stagnation. Nor is this coincidence accidental. It is not—because the rigor disappears as the system rallies, and ceases when the pulse and heat return: it is not—because it reappears in the form of subsultus when the feverish turmoil is past, and when death is at hand.

In mercurial tremor the pulse gives the same indications as it gives in ordinary tremor or in chorea, and this is proved by the general practice which prevails among the subjects of this disorder of resorting to stimulants to make themselves steady.

2. When convulsion happens at the commencement of fever it takes the place and has the accompaniments of rigor. The pulse is quick and feeble, or else imperceptible; and the general state is one of asphyxia or syncope, and not of fever. This is proved by the sequel: for the convulsion passes off as the reaction of fever is established,

and it returns when this reaction has died away, and when the system begins to shudder under the chills of approaching death. In this case, indeed, it is convulsion and collapse, and not convulsion and fever which go together.

In hydrophobia the state of the circulation is the very opposite of fever. This is proved by the cold hands and feet, the perspiring skin, the quick and feeble pulse, the sobbing and sighing respiration, as well as by the fact that the agitation and spasm and convulsion increase rather than diminish, notwithstanding the continually progressing exhaustion of the circulatory energy. Sometimes, as in a case lately related by Dr. Lawrie of Glasgow,* the pulse is more active. In this case "the pulse was 150, regular, but not strong," but evidently stronger than usual. But there was also far less convulsive disturbance than usual, and the symptoms were more like those of acute hysteria than anything else. "The globus and incessant tossing," writes Dr. Lawrie, "were well marked; but although the desire to move was irresistible, the movements had no appearance of being involuntary or associated with insensibility." Cases like this, therefore, where the circulation is not so absolutely depressed as usual, only tend to prove that this very depression is connected with the spasm and convulsion.

In the convulsion connected with lead poisoning the state of the circulation is as in epilepsy: in hydrocyanic acid poisoning this state is indicated by coldness, paleness, and by failure of the pulse and heart: in the convulsion

* 'Edinburgh Monthly Journal of Medical Science,' for August, 1852.

consequent upon the retention of urea in the blood, by cadaverous coolness and odour, by fluttering pulse and hiccup.

— The state of the circulation in the convulsion consequent upon brain disease is not less marked.

If convulsion arises in connexion with cerebral determination or congestion, all active febrile symptoms have either subsided, or they have never existed. The hands and feet are cool or cold. The pulse is weak and quick, and in the fit it is arrested more or less completely by asphyxia or syncope. The subsequent reaction may be very rapid, but it is never so rapid as to overtake the convulsion. The head, it is true, is warmer than the rest of the body, and the warmth often increases during the fit, but when so, it is clearly owing to asphyxial engorgement of the veins, for the arteries, as judged by the pulse at the wrist and in the neck, are comparatively empty. The head is often only warm as compared with the cold feet and hands of the patient, but not as compared with the head of a healthy person. In many cases, also, the head is as cool as the rest of the body, and the pale cold cheeks are unmistakeable evidences of the faulty circulation in the neighbouring brain. This is when the collapse of the fit partakes of the character of syncope.

So, also, with the convulsion connected with inflammation of the brain and its membranes. If the paroxysm does not occur in place of rigor during the stage of primary depression, it is deferred until all febrile and inflammatory symptoms have passed off. The quick and

feeble pulse, and the remarkable increase in frequency on any exertion, show how profoundly the circulatory powers are depressed when the time for convulsion has arrived, and asphyxia or syncope are still present in the fit itself. Here, as in the former case, the fit remains in abeyance so long as the cheeks are hot and red.

In like manner convulsion never happens in apoplexy so long as the carotids throb with energy, and the cheeks are scarlet; but it happens often enough when the throbbing has died away, when the cheeks have lost their bright colour, and when the system is depressed and stupefied by the circulation of unaërated blood. It happens often enough, also, in that form of apoplexy in which the insensible and unconscious patient is cold and pale and comparatively pulseless.

The same rule applies to the convulsion connected with inflammation of the spinal cord or its membranes, for at the time of the fit, the fever has not yet been developed, or it has subsided, and the skin is cool and perspiring, the respiration laboured and hurried, and the pulse rapid and feeble.

In all those cases, indeed, where mischief in the great nervous centres is the main cause of the fit, the rule is absolute and without exception, that there is neither fever nor active determination of blood to the head at the time of the convulsion. This rule may perhaps be doubted by the person who forms his idea of the state of the circulation in the fit from the state of the circulation when he reaches the patient,—when indeed a sufficient interval has usually elapsed to allow collapse to change into reaction;

but it will not be doubted by any one who has had opportunity and patience to watch a few cases in the actual fit.

— The circulation in hysterical people is always deficient in vigour. The hands and feet are habitually cold, and there is, in a very marked degree, that inequality of the pulse, and that great proneness to excitement and depression, but particularly to the latter, which has already been insisted upon as a frequent symptom in these maladies. In the fit, this depression, which is always present and always great, often amounts to actual syncope.

In convulsion from flooding there can be no doubt as to the real state of the circulation, for the whole train of circumstances is precisely analogous to that which happens in an animal at the shambles. In the other kind of convulsion connected with labour there is more obscurity, though not necessarily so. The coldness of the hands and feet, and the obvious indications of impending asphyxia or syncope during the fit, are indeed inconsistent with any state but one of great depression in the circulatory powers. The fulness of the head, which is generally present, is explained by the dark colour and by the evident engorgement of the veins. It is the consequence of asphyxia and not of arterial injection, as, indeed, is sufficiently shown in the state of the respiration and of the pulse. In this case more than in any other, the vascular reaction after the fit would seem to be most rapid, and for this reason there is a greater risk of overlooking that period of collapse which coincides with, and belongs to, the convulsion, if the changes of the pulse are not patiently watched throughout.

In convulsion depending mainly upon causes inherent in the alimentary canal, as from teething or worms, the same law holds good. Fever has given place to collapse, the hands and feet are cold, and if the head is warmer than the rest of the body, the colour and the state of the pulse, afford sufficient proof that it is brought about by the venous congestion which results from impeded respiration.

And, lastly, this law receives its final confirmation in the convulsion associated with dissolution, and in that which occasionally happens *after* death, for in these cases the heart and lungs are relinquishing or have relinquished their functions, and the blood is either stagnating or stagnant.

3. The state of the circulation in laryngeal spasm is readily determined. The want of everything like fever in laryngismus stridulus is clearly proved, and so is the same want in the spasmodic stage of hooping cough. In the latter case the hoop, which is the sign of the spasm, does not make its appearance until the primary or catarrhal stage has passed off. It disappears, also, if pneumonia, bronchitis, or any inflammation happen to be developed during the course of the disease; and it returns again as soon as the inflammation has subsided. In this way the utter uncongeniality of laryngeal spasm and inflammation or fever is clearly shown; and on the other hand, the way in which this spasm is mixed up with the phenomena of asphyxia is a seeming argument that it is really concurrent with the opposite of fever and inflammation—collapse.

In the spasms of cholera the skin is cold and clammy and blue, and the pulse is imperceptible or nearly so; and that this coincidence is more than accidental, is evident in the fact that the muscles relax as the patient rallies, and *pari passu* with that rallying.

In tetanus, again, there is no fever. All observers are agreed upon this point. But more than this, the extremities become colder and colder, and the pulse becomes quicker and feebler, and concurrently with these changes, the spasms become more general and more violent. Indeed, whatever may be the state of the circulation at the beginning, there can be no doubt that it is one of great and increasing collapse when the malady is fully formed. In tetanus, indeed, the condition of the circulation fluctuates, and there are occasional attempts at feverish flushes, but these flushes coincide with temporary and partial lulls in the pangs, and not with the pangs. In tetanus, however, there is a source of possible error which must not be overlooked, and this is in the occasional flushes of congestion and warmth in the skin. These flushes appear to be caused, partly by the blood being driven from the muscles by their contraction upon the vessels enclosed in them, and partly by the blood being diverted to the surface of the body by the operations of that law of compensation by which the skin is made to do duty for the lungs when these organs are unequal to the necessary amount of respiratory action. Under any circumstances, however, the feebleness of the pulse is a clear proof that warmth of the skin is not a symptom of active fever.

In partial cramp the circulation in the part is always

very inactive. In a little patient of my own, whose hands and feet were particularly liable to become stiffened in this way, no pulse could be detected in the wrists or ankles at the time.

In ergotism the condition of the circulation appears to correspond very exactly with the premises.

In catalepsy, the blood is nearly stagnant; in rigor mortis, it is not only stagnant, but dead.

— In all these affections, therefore, there is a decided want of vascular power, and tremor, convulsion, and spasm are all found to be directly dependent upon this want. Fever and inflammation have no part in the process, except now and then as preliminary means by which the strength of the patient is exhausted. *Plethora, as it is seen in the butcher, is never met with*, and this is the only kind of plethora in which there is any evidence of vascular activity; indeed, that kind of plethora, in which venous congestion is a marked phenomenon, and in which all the other symptoms denote vascular *in*activity, ought not to be designated by the same name as the other, if entire difference of nature be any reason for difference of name. There are, indeed, occasional feverish flushes which without care might be mistaken for plethora; but these flushes are consequent upon the heat of the room or of the weather, or upon some transitory excitement, as is evident in the ready and rapid way in which they disappear when the patient is removed into a cold place, or when the excitement is at an end. Nay, even without these changes, they ought not to be regarded as indications of active plethora, for their venous

complexion, and the feebleness of the pulse at the time, are quite at variance with such an idea.

There is another question which bears somewhat upon the condition of the vascular system in these affections, and which must be noticed before leaving this part of the subject, and this is the remarkable manner in which the vessels are emptied of fluid in some instances. They are so emptied by excessive discharge of urine in all kinds of trembling, in all cases of hysteria, and in many cases of epilepsy. They are so emptied by excessive menstruation or by direct hæmorrhage in some forms of convulsion. They are so emptied by excessive diarrhœa in many cases of subsultus and in all cases of cholera. This emptying, indeed, is a fact of too frequent occurrence not to have some significance. Now, it *may* indicate a state of contraction in the fibrous elements of the vascular coats, by which the vessels are rendered incapable of holding their former contents—the contraction itself being analogous to that which is taking place in the muscular fibre elsewhere, and referring to the same cause for its origin,—in other words, it may indicate a tremulous, or convulsive, or spasmodic condition of the irritable fibres of the coats of the vessels; but, be this as it may, the discharge indicates an equivalent emptying of the vessels, and this emptying implies inactivity of the vascular system, if, as the reasonings contained in the second chapter of the first part of this work go to show, expansion and dilatation are the true signs of vascular activity.

II.

Before proceeding to the investigation of the condition of the *nervous system*, it is well to premise that the term *nervous*, by which these affections are usually designated, is itself an argument that they are not marked by undue nervous activity, for, by a complete perversion of its true meaning, this word has come to signify the very reverse of any kind of activity. It is also well to premise —in answer to a popular fallacy which has been encouraged by the loose nomenclature of many medical writings—that convulsion is not violent voluntary effort. So far from this, there is not the remotest analogy between the two conditions, for in the one case the will is passive, and in the other active. The muscular contraction in convulsion is violent enough, but, whatever its cause, it is independent of voluntary effort. But to proceed—

1. During the state of ordinary trembling the thoughts and feelings range at random, and the mental energies are all unnerved. In old age, more particularly, every faculty of the nervous system has given way under the accumulated feebleness of years.

In chorea the mental faculties are said to be unaffected, but this assertion is plainly at variance with the fact that the unchecked disease goes on to fatuity. There is no stupor during the paroxysm, and this may probably be the reason for saying that the mind is undisturbed; but if want of memory, want of purpose, and want of will, be any proof of such disturbance, the proof is never wanting. Want of will, indeed, is so marked, that the patient is not able to coerce his muscles into obedience.

The scalpel reveals nothing of any moment, and certainly nothing to the contrary.

In paralysis agitans the whole group of faculties which constitute the thinking and sentient man have given way before the inroads of age or of some other blighting influence, and the patient only lives to fear and eat.

The mental state in delirium tremens is passive in every point of view. The patient is in a state of helpless fear or dread, and at every fresh impulse his thoughts course timidly from one object of fear and dread to another. He lies unmanned before a dim prospect of undefined evil. A fierce and hilarious delirium sometimes arises under the same circumstances as delirium tremens, and when it does—when, in fact, the symptoms indicate inflammation or active congestion of the brain—then the affection is *delirium e potu*, but not *delirium tremens*. The tremor is wanting.

In rigor the state is one of dejection, languor, and stupor; in subsultus, of wandering silliness.

In slow mercurial poisoning the failure of the mental has kept pace with that of the bodily strength, and the condition is one of premature old age.

— In these several forms of tremor, therefore, the condition of the nervous system, as reflected in the mental phenomena, is one of comparative inactivity. It is in harmony with the condition of the vascular system, as indeed it must needs be, for how the one can be inactive and the other active does not appear on any known physiological law. There is, however, one apparent objection to this view, and that is, the cessation of tremor

which almost always takes place during sleep. If inactivity of the nervous system be a cause, the natural impression is that the very reverse should be the case. Still this is not a necessary conclusion. Inactivity of the nervous system is only one of several causes. Inactivity of the vascular system is indeed another, and, perhaps, a still more important cause, and this may be remedied by the warmth of the bed. Muscular weakness (as will be seen presently) is another cause, and this will be less tried while the body is lying in the recumbent posture. And besides this, it is perhaps gratuitous to suppose that the nervous system is less active during sleep than during trembling. Often during trembling the mind is under the influence of fear, and, still oftener, of timidity, and how much the nervous system may be depressed under these circumstances it is impossible to say.

2. The convulsion of fever, whether it occur at the end or at the beginning of the malady, in adults or in children, is accompanied by absolute insensibility and unconsciousness.

This is not the case in hydrophobia, except occasionally in the last moments of life, but everything denotes the want of all true mental activity. The real state is very like that of delirium tremens. The patient is overcome with dread, and absorbed in his sufferings, but he is as devoid of all true and voluntary energy as is a child. The same extreme sensibility to light, to sound, or to other impressions on the senses, is often met with in cases of nervous exhaustion, and if it has any meaning, it is that the person so circumstanced, is the helpless

slave of surrounding objects, instead of being superior to them. Nor is the congested medulla oblongata which is met with in some cases of hydrophobia, any proof that over-activity of this part of the nervous system is necessary to the convulsive phenomena of this disorder. This appears from its inconstancy, from the absence of any such phenomenon in other forms of convulsion, but chiefly from the presence of the congested gullet, of which, indeed, the congested medulla is but a part—a part by contiguity of textures.

In convulsion from lead poisoning there is the same want of consciousness and sensibility as in epilepsy. In hydrocyanic acid poisoning the mind is in a profound swoon; in urea-poisoning it is overwhelmed by stupor or coma.

—The convulsion connected with disease of the brain, whether this be determination of blood and congestion, or inflammation, or apoplexy, is attended by insensibility and unconsciousness. If any excitement existed it has died away previously. The real inactivity of the nervous system is also seen in those chronic and partial cases where the muscular disturbance is confined to one side of the body, for here—provided the muscular structure has not disappeared altogether—the tremors, or cramps, or convulsive starts, evince a preference for the paralysed and not for the sound side. These cases, indeed, reveal the real inactivity of the nervous system in spasmodic disorders, as in an experiment. Nor are there any real discrepancies in the appearances after death. These may be indicative of inflammation or of degeneration. If of the former,

everything turns upon the question of time. Are they traces of a past mischief, or are they not? Did the symptoms by which they were indicated during life coincide with the convulsion, or did they not? If they did not, and every fact in their clinical history shows that they did not, then the only logical conclusion must be that they are foreign to the question, except, perhaps, as showing that the brain has been maimed by the disease, and that its natural powers have been weakened to that extent.

The convulsion connected with inflammation of the spinal cord and its membranes is not attended by unconsciousness and insensibility, nor is it attended by delirium, if the brain be unaffected. There is, however, acute pain, and it may be asked whether this is not an argument that the great nervous centres are in a state of exalted activity. By no means. On the contrary, pain seems to be most intense when it is purely nervous—when, that is to say, it is without any febrile or inflammatory accompaniment, and when it demands stimulants for its relief. This is a matter of every-day experience. Even in actual inflammation of, or increased flow of blood to, the brain, it is by no means certain that pain is *always* symptomatic of increased arterial injection. So far from this, there are many cases in which the pain ceases and gives place to delirium when this arterial injection becomes evidently and unmistakeably increased, and where, on the other hand, the delirium ceases and gives place to pain when the injection passes off. This fact—which has not been sufficiently attended to—acquires a new and peculiar significance in connexion with

some recent experiments of M. Dubois Reymond* which serve to render it extremely probable that the nervous energy of a nerve is *lessened* during pain. In these experiments it was found that the galvanometer invariably indicated the disappearance of the electricity previously present in the nerve whenever that nerve was treated in such a way as to cause pain. These experiments, it is true, have been only tried upon the nerves of frogs, and the influence tested by the galvanometer is electrical and not nervous, but still there is every reason to believe that the nerves of frogs are obedient to the same law as the nerves of man, and there is much reason to believe that electricity and nervous influence are correlated in such a way that the state of the one may be taken as an indication of the state of the other; and hence these experiments are full of significance, and they may be supposed to furnish *some* reason for believing that pain is as much the sign of want of activity in the nervous fibre as spasm is the sign of want of activity in the muscular fibre. Be this as it may, however, the condition of the nervous system in the case in question is one of comparative collapse. The previous fever has passed off, and this fact, together with the absence of any sign of excitement in the mental faculties, furnishes an irresistible argument against the idea that the pain is the sign of any over activity in the spinal cord or in its membranes at the time of the convulsions. Indeed, whatever the nature of pain generally, there can be no

* 'On Animal Electricity: being an Abstract of the Discoveries of Emile du Bois Reymond:' edit. by Bence Jones, M.D., F.R.S. Ch. xxvii.

rational doubt that pain in this case is the sign of defective action in the nervous system, for with the collapsed condition of the circulation no other conclusion is possible. The morbid appearances in themselves are literally worthless. If they indicate inflammation, everything turns, not on the mere fact of their existence, but on the time of their occurrence. It is a question for the bedside and the timepiece, and not for the deadhouse, and the answer elicited is—that inflammation as inflammation has nothing whatever to do with convulsion, except as antagonizing it.

In hysteric convulsion the patient is in a state approaching very closely to unconsciousness and insensibility. At other times she is wanting in all real energy, and especially in firmness of will and purpose. She is a creature of passion and not of action, and she is most the sport of passion when the train of events is in progress which ends in the fit.

Convulsion connected with childbirth, with dentition or worms, or with death, is accompanied by a total eclipse of every mental faculty, and in the last case that eclipse is final.

— In all cases of convulsion, therefore, the condition of the nervous system, as reflected in the intellectual and sentient faculties, is that which is necessitated by the condition of the vascular system; and this conclusion is further borne out by the fact that convulsion most frequently happens during the mental quiescence of sleep.

But is this all? Is there no peculiar state of the nervous system during convulsion? Is there no *irrita-*

tion? In order to answer this question it is necessary to ask another. What is irritation? It is not inflammation, —it is not fever,—but it is some indefinable and negative state which is often seen in worm-disease, in teething, or in uterine derangement, and in which the patient is unnaturally sensitive to the various influences acting upon the body. But what is this? Is it a definite condition, or is it a mere symptom of some other condition? In convulsion from worm-disease the system is starved by its hungry parasites; in convulsion from dentition the strength is worn away by pain and want of sleep; in convulsion from uterine derangement the health is undermined by pain or by sanguineous and other exhausting discharges;—in each case there is unequivocal exhaustion of mind and body; and if so, does it not follow that the symptoms of *irritation* are a necessary part of this condition? A weak person is more affected by the vital and physical agencies which act upon him than a strong person, because he has lost some of that innate principle of strength which enables the strong person to contend against these agencies. In other words, the weak person is more *irritable* than the strong person, for every idea which is implied in this condition of irritability appears to be implied also in the condition of a person who is unnaturally sensitive to the various influences which continually act upon his being.

3. Spasm, in like manner, is related to a greater or less degree of nervous inactivity. Spasmodic closure of the larynx is most apt to happen during sleep. The cramps of cholera are attended by indifference as to the

future, or by hopelessness, than which there are no surer signs of mental prostration. In tetanus the patient is agitated, alarmed, and absorbed in his sufferings, but he is never excited. Common cramp is most prone to happen during sleep, and the liability to this affection is infinitely increased in a state of fatuity. The mind is in abeyance in catalepsy, and when otherwise its manifestations are only those of a dreamy and imperfect consciousness. In cadaveric rigidity all earthly joys and troubles are at an end.

— Such, then, is the evidence which is furnished by a review of the condition of the nervous system in the several forms of tremor, convulsion, and spasm; and in this evidence there is most unequivocal proof of *under-activity*, and none whatever of *over-activity*.

III. There are some disorders which seem to show at one and the same time, that the condition of the *muscular system* in the affections allied to epilepsy, as in epilepsy itself, is the very reverse of anything which can be supposed to denote activity and strength. There are, indeed, many cases of hemiplegia, in which the paralysed side is atrophied and yet subjected to continual tremor, convulsion, and spasm, while the other side is plump and free from all unnatural movements. Here the tremor, convulsion, and spasm are unquestionably coincident with wasting of the muscular substance and with loss of voluntary power, and this wasting and want is all the more evident from the marked contrast presented by the other side. Nor are these cases peculiar.

1. In the common tremulousness of early life the presumption is that the muscles are more delicate than usual, because delicate women and delicate people generally are those who are annoyed in this way. In old age, and especially in old age accompanied by palsy, the trembling muscles are weak, wasted, and often more or less degenerated into fat. In chorea the muscles are decidedly wanting in fulness, strength, and reparative energy; and in old cases they are soft and pale, so as to bear some resemblance to the muscles of white-fleshed animals. In delirium tremens all real muscular strength is abolished, and so also, and still more decidedly, during rigor and subsultus. In confirmed mercurial trembling the condition of the muscles is similar to, if not identical with, that which is found in bad cases of chorea.

2. The fact that convulsion happens most frequently in women and children, and in those too who are manifestly more delicate than others, is an argument that muscular strength is not necessarily associated with convulsion. It is obviously the very opposite of strength in the convulsion of fever, for the system is even more prostrated or exhausted than it is in rigor and subsultus. In hydrophobia the real state is less apparent, but it is in no way contradictory; indeed, the fact that the convulsions continue with equal severity, and often with increasing severity, in spite of the rapid and progressive exhaustion, is an argument, to say the least, that muscular strength is unnecessary to them. The lassitude, also, which invariably precedes the outbreak of the confirmed disorder is another argument to the same effect.

In the convulsions of dissolution the muscles are in a very variable state; they may be emptied of blood by hæmorrhage, or wasted to mere threads by chronic disease, or disorganised by the workings of putrid poison, but they are always exhausted, and that to the very last degree.

3. The state of the muscles in the spasmodic form of muscular disorder is virtually the same as in the two other forms. In cholera the muscles are divested of all power of responding to the will; and so also in tetanus. In tetanus, moreover, it might be argued that the spasms are coincident with prostration of muscular strength, because they undergo no mitigation, and often augment in violence in spite of the progressive failure of this strength; but there are two valuable observations by Mr. Bowman upon the actual state of the muscles in this affection which leave no reasonable doubt upon this point. The appearances are thus recorded. "1. Many muscles appear healthy in all respects. 2. Parts of certain muscles present a remarkable grey aspect, arising doubtless from their blood having been pressed out by the contraction, a state of which the appearance has been aptly compared by my friend Professor Budd, to that of the flesh of fishes. 3. In other situations, the muscles have lost in great measure their fine fibrous character, and present a soft mottled surface, which readily tears, and receives an impression from the contact of the finger. 4. Extensive ecchymoses, often contrasting strangely with the pallor of contiguous portions."*

* 'Phil. Trans.,' 1841, p. 69.

Again, common cramp is often associated with delicacy and weakness, and often with unmistakeable atrophy, as in palsy, and particularly in the palsy caused by lead-poisoning, where, indeed, the red structure may be entirely lost. Catalepsy is closely akin to hysteria and chorea, and the evidences of muscular debility are equally apparent. Rigor mortis, again, is coincident with absolute death of the muscles. It cannot, as is generally supposed, be referred to some lingering vitality in the muscles, for the time of its accession is inversely related to the degree of this vitality,—that is to say, it occurs soonest in muscles the strength of which has been previously exhausted by old age or by chronic disorder, such as consumption, and delays longest in the case of muscles whose strength is retained at death, as in persons who have been cut down in the full vigour of health. The accession of rigor mortis, indeed, coincides with the departure of animal heat; and this departure, as is well known, is longest delayed in strong and vigorous persons. This delay, however, must not be confounded with that want of cadaveric rigidity which is sometimes noticed in persons who have died from typhus or from the bites of venomous serpents, for in these cases the blood has lost its coagulability, and the muscles their contractility,—and the muscles, therefore, are no longer muscles.

— In the majority of instances, therefore, the muscles are in a state of debility, atrophy, degeneracy, or prostration—one or more,—and in the few cases in which there might be any doubt, the preponderating evidence is to the same effect. In no one instance is there the least

sign of hypertrophy or over-activity, and hence the conclusion respecting the state of the muscular system harmonises with the previous conclusions respecting the states of the vascular and nervous systems.

II.

The causes which operate in the induction of these affections are similar to those which operate in the induction of epilepsy, and such as might be expected from the condition in which the vascular, nervous, and muscular systems are found to be.

1. The causes of trembling are very apparent—cold, hunger, fatigue, fear, and the like,—causes of whose true causality instinct and experience alike afford assurance. This is the case with all kinds of trembling, whether occasional or permanent. The same rule applies to chorea. Cold and fright are perhaps the commonest initiatives, and hunger and fatigue the commonest adjuvants. When chorea originates in fright, it may be said to be a continuation of that *startling*, which all persons experience under similar circumstances. The tremor of delirium tremens is the result of the stoppage of some physical or mental stimulus to which the system had been habituated. Rigor refers most generally to a zymotic poison, whose influence may be presumed to be of a depressing nature; and subsultus, like the trembling just mentioned, is due to the cessation of some previous excitement. In all these cases, the real nature of the causes at work is further manifest in the fact that the opposites, such

as warmth, food, wine, rest, and hope, invariably afford relief.

2. The frequent occurrence of convulsion at night is an important fact in connexion with the causes of this disorder. It is common to all convulsions, and is of great significance in connexion with the foregoing considerations; for at night the vital stimuli supplied to the body from without are much less energetic than those which are supplied during the day. In hysteric convulsion the causes which operate are obviously similar to those which induce trembling and choreic agitation, and such as might be expected from the manner in which startling and violent chorea blend into this form of convulsion. In convulsions from fever a depressing poison has been at work; and so also in hydrophobia, if indeed the animal poison in this case does not differ from other animal poisons, all of which are depressing, and some frightfully so. In convulsion from hæmorrhage and from other modes of death the nature of the efficient cause is sufficiently obvious.

3. Exposure to cold, particularly at night, is a common, if not the commonest cause, of the minor forms of spasmodic disorder. All are agreed that the immediate cause of cholera, and therefore of cholera-cramps, is depressing and not exciting, in its character. It is the unanimous opinion of army surgeons that tetanus is most apt to occur when soldiers are dispirited, exhausted, ill-fed, and exposed to cold. There is no doubt that wounds are a most important cause of this disorder, but it is altogether gratuitous to suppose that they have acted by

exciting inflammation. There is every reason to believe that they have often acted by depriving the patient of blood, by the shock to the system, or by the natural depression resulting from the thoughts of danger or of a maimed and helpless future; but, judging from the histories of cases, there is not a tittle of evidence that they have ever acted by exciting inflammation in the nerves or in any other tissue, for even where the effects of such inflammation have been found after death, the symptoms during life have sufficiently shown that the inflammation itself had died away long before the supervention of the spasms. There are several facts which serve to show the especial influence of cold in inducing trismus, and among these is the curious increase in the frequency and mortality of this complaint which happened at a hamlet in the island of Cayenne, after some forests had been cut down which had sheltered the place from the cold sea-winds. This fact is related by M. Romberg on the authority of M. Bayon. Exposure to cold, again, is a most frequent cause of catalepsy. In a patient of my own, to whose case reference has already been made, the rigidity was often induced by playing out of doors in cold weather, or by undressing in a cold room; and this rigidity would continue until it had time to thaw before the heat of the fire or of the bed. Last of all, cadaveric rigidity is the work of death.

In a word, the causes of tremor, convulsion, and spasm are of such a character as to confirm the deductions arising out of the *condition* of the vascular, nervous,

and muscular systems; and the condition of these systems reacts in confirming the idea that these *causes* are, as they seem to be, of an anti-vital character.

In conclusion, therefore, it must be admitted that the entire history of epilepsy and of affections allied to epilepsy is at complete variance with the idea that the muscles are provoked to excessive contraction by excessive stimulation. It is as much at variance with this hypothesis as it is in harmony with that doctrine of muscular contraction which was propounded at the commencement of this enquiry, which doctrine is—that all stimulants, vital and physical, antagonise muscular contraction, and that contraction is brought about by ordinary molecular attraction when the muscle is *not* stimulated. This doctrine, indeed, supplies the key to the pathology, and the facts belonging to the pathology furnish the only proofs which were wanting of the truth and universality of the doctrine.

CHAPTER III.

ON PERIODICITY.

The consideration of the pathology of these disorders is far from being complete if the question of Periodicity be passed over. It is far from complete, in a practical as well as in a philosophical point of view, for a most important rule in treatment depends upon its solution.

In entering upon this question, the natural and only course is to leave the bedside for a time, and to attempt to acquire a clear conception of the periodical phenomena which are manifested in the healthy lives of plants and animals, and of the causes upon which they depend. Of these phenomena the plainest and simplest are such as are witnessed in the sensitive plant and in the common newt,—and the consideration of these examples will serve as a proper introduction to the rest of the subject.

The periodical changes in the life of the sensitive plant are both plain and simple. In spring the seedling emerges from the cradle in which it had slept during the winter; in summer it puts forth its foliage; in autumn it droops; in winter it dies. In spring it

gives new signs of life; in summer it regains its verdure; in autumn it fades; and in winter it again becomes a bare and lifeless twig. Year by year these phenomena succeed each other with unfailing regularity, and the vitality ebbs and flows in direct relation to the ebbing and flowing intensity of the sunbeams. At daybreak, also, the leaves recover from the closed and pendent condition in which they had been all night, and—if not disturbed in any way—they remain erect and unfolded until evening, when they again close and droop; and these changes alternate with perfect regularity so long as the leaves retain their characteristic irritability. In each case the vital movement corresponds with certain changes in the relative positions of the earth and sun, the one referring to the annual, and the other to the diurnal revolution.

The periodical changes in the life of the newt are not less plain and simple than those which occur in the life of the sensitive plant. The egg, like the seed, exhibits no signs of development except it be quickened by the sunbeams; and the animal, like the plant, continues dependent upon the same fostering aid throughout the whole course of its future life. As spring advances it grows day by day into a more active and sentient being; as autumn wanes it droops by degrees into a state of unbroken sleep. This winter-slumber passes off at the renewal of spring, and returns at the end of autumn; and these changes are repeated through succeeding springs and autumns with as much regularity as the corresponding changes in the sensitive

plant. In the active period of its existence, also, the newt wakes in the daytime, and sleeps during the night. In a word, the life of this creature appears to be as closely wedded to the sun as that of the sensitive plant, and yet that life embraces a sentient principle which is endowed with memory and other mysterious gifts.

These changes are also reflected in other plants and animals.

The woods and fields of this country are bare and desolate in winter, and the few trees and plants which retain their verdure are half-deprived of life because the sun has withdrawn his warmer rays. The shores of the arctic seas are carpeted with scanty patches of moss, and the banks of the Amazons are hidden under an impenetrable and unbroken tangle of forest trees, because the pole does not share in the perennial summer which descends upon the equator. A brief winter may even be said to reign during the night, for on passing within the arctic circle the seasons of winter and night are found to become confounded and identical.

The animal world exhibits the same obedience to the seasons. The fish which has been born in the polar seas during the summer is compelled to forsake its birth-place before the winter, in order to follow after its parent luminary. The frog sleeps soundly under the waters of the frozen pond. The swallow appears in the spring and departs in the autumn; or if she remains, she forgets her solitude and sleeps until the chirp of her companions is borne upon the gales of returning spring. In winter, indeed, the fields and woods of

this country would be desolate, if some visitors, like the robin, were not driven here from less hospitable climes. The bat loses its bird-like energy, and sleeps while the swallow is away. The marmot is only nimble during the summer, and at other times it must either sleep or follow the day in its southward course. Animals, also, which live in the winter are still the subjects of the same law, for though they are clothed in warmer vestments, they have lost that vital heat, the overflowing of which provides for the renewal of their own life in that of their offspring.

The diurnal changes in the life of the newt are reflected also by diurnal changes in the lives of other animals. Sleep still attends upon night, and wakefulness upon the day. At sunset, the butterfly descends from the sky, the snail withdraws within her shell, the dace lies motionless in the pool, the frog ceases to leap across the path, the lark folds his wing and hushes his song, the deer retires to his lair, and sleep reigns over them throughout the night; but when the dawn illumines the east the spell is broken, and all are released to life and enjoyment until the evening, when sleep resumes her lost mastery. And that sleep is caused by the night, and wakefulness by the day, may be argued from those changes by which the periods of sleep and wakefulness are made to correspond at all seasons to the continually changing periods of night and day. The sheep, for example, sleeps from sunset to sunrise, and wakes from sunrise to sunset, and this it does throughout the year.

It cannot sleep, therefore, because it is exhausted from having been awake, for the slumber is briefest and lightest after the accumulated fatigue of a midsummer day, and longest and heaviest when winter has most abridged the period of daily exertion. The times of renewal and waste are inversely related to each other. But the slumbers may be expected to observe the law they do obey, and be brief and light in summer and long and heavy in winter, if the energy of waking life is derived from the sun, for then the animal *must* wake in the daytime and sleep at night, and the periods of wakefulness and sleep *must* bear an exact correspondence to the changing periods of day and night. The fact, therefore, that there are these changes and correspondences, and that it is impossible to account for sleep as a consequence of wakefulness, or for wakefulness as a consequence of sleep, is a powerful argument that those animals whose names have been mentioned, and with them the great multitude of living creatures, wake and sleep in implicit obedience to the rising and setting sun.

Arguing from a fact connected with "the nocturnal life of animals in primæval forests" which is related in the 'Aspects of Nature,' it would even seem that the moon has some share in the sleep-dispelling power which belongs to the sun. Humboldt writes:—"Soon after 11 o'clock such a disturbance began to be heard in the adjoining forest, that for the remainder of the night all sleep was impossible. The wild cries of animals raged through the forest; and among

the many voices which resounded together, the Indians could only recognise those which, after short pauses in the general uproar, were first heard singly. There was the monotonous howl of the howling monkeys, the plaintive, soft, and almost flute-like tones of the small sapajous, the snorting grumblings of the striped nocturnal monkeys, the interrupted cries of the great tiger, the cuguar or maneless American lion, the peccary, the sloth, and a host of parrots or parraquas, and other pheasant-like birds. When the tigers came near the edge of the forest, our dog, which had before barked incessantly, came howling to seek refuge under our hammocks. Sometimes the cry of the tiger was heard to proceed from amidst the high branches of a tree, and was in such case always accompanied by the plaintive piping of the monkeys, who were seeking to escape from the unwonted pursuit." This turmoil, it must be observed, occurred when "the night was humid, mild, and *moonlight*." The Indians accounted for it as a consequence of the moonlight, and said that "the animals were rejoicing in the bright moonlight and keeping the feast of the full moon." Humboldt accounts for it by ascribing it to some accidental combat—"the jaguar pursues the peccaries and tapirs, and these pressing against each other in their flight, break through the interwoven tree-like shrubs which impede their escape; the apes on the tops of the trees being frightened by the crash, join their cries to those of the larger animals; this arouses the tribes of birds which build their nests in communities, and thus the whole animal world becomes

in a state of commotion;"—and this may be the explanation occasionally. But the frequent connexion with the full moon is admitted, and this is the question of interest here. Is it that the nocturnal riot on the banks of the Cassiquiare, when the wild animals are "keeping the feast of the full moon," and the baying of the mastiff in the English homestead on the same solemnity, are parallel phenomena? For if they are, then the two facts afford a double reason for supposing that the moon is endowed with some degree of that vivifying power which belongs to the sun.

There are, also, certain familiar facts which serve to prove that artificial light and heat have a sunlike influence upon plant and animal. The daisy wakes throughout the night in a well-lit room. The sensitive plant lives during the winter under the fostering shelter of the hothouse. The imprisoned squirrel does not hybernate in the kitchen; and the snail sleeps soundly through the summer in an icehouse. These facts, which are taken at random from a multitude of others of the same kind, are of great interest in themselves, but they are of greater interest as confirming the conclusions which have been arrived at respecting the vivifying power of the sun, and as rendering it more than probable that the moon has some share of a similar energy, for if this vivifying power belongs to artificial light and heat it is impossible to conceive that it does not belong to natural light and heat.

— It is clear, however, that the sun and moon are not the sole springs of life, for there are animals which

sleep in the day-time and wake at night, and there is man, who sleeps and wakes without any apparent regularity. And so it should be.

In the case of man, the periods of sleep and wakefulness must occur at irregular intervals, because there is no regularity in the times of meals, or in the moods of pain and pleasure. Food supplies fuel, by the burning of which the Laplander is able to keep himself warm throughout his sunless winter. It feeds a fire which does the office of the sun so far as he is concerned, and what it does for him it does for all. If, therefore, the food be taken irregularly the warming and vivifying effects which result from that food must occur irregularly, and as it is so taken they must so happen. Again, pain depresses and pleasure excites, and as these different moods occur without any definite order there can be no definite order in the states of depression or excitement which result from them. Even the pain of hunger is sufficient to drive away sleep. In man, therefore, the mere irregularity which exists in the times of meals and in the moods of pain or pleasure is sufficient to account for the want of any fixed periods of sleep or wakefulness.

On the same principles it is easy to understand how some animals should wake when others are asleep. The animals which thus wake are supplied with richer food and they are gifted with acuter feelings than other animals, and these facts have a direct bearing upon the difference of their habits. If food exerts so decided an influence upon man it may be expected to affect them similarly. If hunger wakes him it may be expected to

wake them. If, then, first of all, it be supposed that these animals were set to discharge their sanguinary functions at night, and that they were provided with appetites to devour a quantity of food sufficient for the wants of twenty-four hours, their hunger would wake them regularly at night—just as it wakes the man who has gone dinnerless to bed; and as they are devoid of any spontaneous power by which they could alter their relations to that law of which they are the subjects, they would continue to wake and sleep in the same order. And that this is the true explanation may be argued from the fact that there is a complete revolution in the habits of lions and other nocturnal animals, by which they are made to wake in the day and sleep at night, when they are confined in menageries and fed in the day-time.

In spite of every cause of perturbation, however, there are many evidences of periodicity even in man. It is something more than accident which so often causes the shepherd boy to sleep or wake with his flock. It is something more than accident which causes man to be stunted, stolid, and passionless in countries where cold reigns without a rival. It is something more than accident which times the periodical changes of women by the lunar orbit. There are, indeed, frequent irregularities in all these cases, and particularly in the last, and these may be supposed to be the natural results of the changing periods of food and passion, but the law is apparent above every irregularity.

It would appear, then, that there are certain periodical changes in vital phenomena which reflect more or less

distinctly the movements of the sun and moon, some of them corresponding to the day, others to the month, and others to the year; and that these changes are more and more conspicuous the lower the grade of organization in which they are displayed,—more so in woman than in man, more in animals at the foot of the scale of being than in those at the summit, and most of all in the plant. Such is the conclusion which arises out of the physiological investigation of the question of periodicity.

— Returning now to the bedside, it may be expected that the signs of periodicity will always be masked and obscure in man, but that they will be manifested most distinctly in him who is most deprived of that active inherent life which constitutes the badge of distinction between man and the plant, and not in the person who is acted upon by inflammation, or who is excited in any other way. And so it is.

There can be no doubt as to the obscurity of the evidences of periodicity even where that obscurity is least, as in epilepsy and in affections allied to epilepsy; but there can also be no doubt as to the existence of these evidences. Thus on looking at a number of cases, it is found that convulsion and spasm occur more frequently at night than in the day, more frequently about the time of new moon than about the time of full moon, and more frequently in the winter months than in the summer months. Of these evidences of diurnal, monthly, and annual periodicity, the diurnal are the most frequent and the best established; but all are sufficiently frequent and obvious to convince any one who will take the

trouble, either to seek after them for himself, or to consult the admirable little treatise of Dr. Mead, 'De imperio solis ac lunæ in corpora humana et morbis inde oriundis.' They are not perhaps sufficiently frequent and obvious to allow any theory to be based upon them, but it is impossible to omit noticing that the greater frequency of convulsion and spasm in the night, at the times of the new moon, and during the winter months, is in accordance with the preceding pathological doctrines, and that being thus in accordance, it is an additional confirmation of the correctness of those doctrines.

There can be no doubt that the epileptic experiences a considerable loss of that inherent life which constitutes the badge of distinction between man and the plant, for his whole history points to this fact. There can be no doubt that the mother suffers from a similar loss when she experiences the recurring heats and chills which are brought about by over-nursing her infant. There can be no doubt that much inherent life has been lost in all kinds of hectic fever, for in this disorder the body is worn away to a shadow and the mind is deprived of all true energy. There can be no doubt as to the reality of the same loss in ague. In all these cases debility and prostration are the prominent phenomena. In all these cases there is no evidence of inflammation or of any other kind of excitement. There is none in epilepsy, or all the premises are wrong. There is none in the weak nursing-mother, for all that is required for her recovery is that she should wean her baby and live generously. There is none in the majority of cases of hectic fever, and in the

remaining few, none can be found except by the keen eyes of him who requires inflammation and excitement to account for all his pathological difficulties. There is none in ague, if any conclusion is to be drawn from the sallow face, and from the beneficial effects of wine and quinine in this disorder.

It appears, therefore, that the signs of morbid periodicity are manifested most distinctly in the person who is most deprived of that inherent life which constitutes the badge of distinction between man and the plant, and not in the person who is acted upon by inflammation or who is excited in any other way; and being so, they furnish an important confirmation of doctrine and a new rule of treatment. The confirmation of doctrine is obvious, for in this point of view the signs of periodicity become only so many additional evidences of that constitutional want of innate strength which appears to be the prominent fact in the pathology of epilepsy and of the cognate disorders. A new plan of treatment is equally obvious, for if the signs of periodicity depend upon a simple want of innate strength, then it becomes necessary to abandon all those leeching and starving plans of treatment which have originated in the supposition that they depended upon internal inflammation, or fever, or some other state of excitement, and to adopt in their stead all those means which are calculated to rouse and invigorate the downcast and flagging powers of the system.

CHAPTER IV.

ON THE TREATMENT OF EPILEPSY AND AFFECTIONS ALLIED TO EPILEPSY.

In entering upon this subject it is desirable to follow the course which has been pursued in the former parts of this inquiry, and to consider the questions relating to epilepsy apart from those which relate to the affections allied to epilepsy.

1. *On the treatment of Epilepsy.*

Arguing from the physiological and pathological premises it may be inferred that epilepsy will have to be cured by strengthening and *stimulating* the system, and not by debilitating and depressing it; and this inference is not altogether at variance with experience. On the contrary, the growing disposition to leave nature to her own course, and the undisguised dissatisfaction with all "lowering measures," furnish a very strong argument against the opinion that these measures are the proper remedies for epilepsy. The necessity for a tonic and stimulant plan of treatment, however, does not rest merely

upon *a priori* inferences, or upon the negative results of a past experience, and this will appear in the sequel.

1. Good substantial food, of which a large portion is beef or mutton, is given to epileptics in many lunatic asylums, and with unquestionable benefit; indeed, the rule of these establishments appears to be that if any difference is made between the epileptic and other inmates it must be in favour of the epileptic. For my own part I am in the habit of recommending a diet which contains an unusual quantity of animal food; and in this recommendation I have a view to the greater digestability as well as to the more nutritious properties of this kind of food. I have had a view to this point because there is often a weakness of digestion which seems to forbid the use of the usual quantities of farinaceous and of green vegetable matters. I have now had many opportunities of seeing the good effects of this plan of diet after a patient has been upon an opposite course; and I am fully convinced that one main reason why, *cæteris paribus*, a poor epileptic has a worse chance of recovery than a rich epileptic is because he cannot command the requisite supply of animal food.

The prejudice against stimulants is very great. Still beer is given to epileptics in many lunatic asylums, and, to say the least, no harm is known to result from the practice. Beer and wine are also given in some exceptional instances out of these establishments, and with apparent benefit. For my own part I am in the habit of recommending a very liberal allowance of stimulants, and I am fully satisfied from the results of this practice

that there is no disease in which they are more needed than in epilepsy. I have notes of cases in which recovery was delayed until the patient had been persuaded to take wine; and I have notes of other cases in which no progress was made because the patient could not get wine. More than once a patient has told me that he has succeeded in warding off a fit by a glass of wine, or by a draught of ale. Indeed, so satisfied am I of the necessity of stimulants from what I have seen of their effects, that I should not have the least hope of benefiting a patient who could not obtain them, unless he could be removed to a more genial climate than that of this country.

It is in keeping with these considerations that epileptics are benefited by coffee, which is a powerful stimulant, and not by tea, which is a sedative. Why it is so —seeing that the active principles of these beverages are analogous or identical—is not easy to say; but so it is. The student takes coffee to keep himself awake and warm. The opium-eater takes it to enhance the stimulant effects of the opium, or to dispel the subsequent drowsiness; and it is given to him if he has over-dosed himself. The inhabitants of hot countries trust to it for dispelling languor and lassitude, and it does not disappoint them. The Arab finds it indispensable on his long journeys. "The hunters of the Isle of France and Bourbon take no other provision into the woods; and Bruce tells us that the viaticum of the Gallas, in their expeditions, consists of balls of ground coffee and butter, one *per diem* (I believe), the size of a walnut, sufficing to prevent

the sense of fatigue."* Coffee, in fact, is a true and potent stimulant. Tea, on the other hand, seems to exert a sedative influence, after the heating effects of the hot water, in which it is infused, have passed off. Tea, also, differs from coffee (in very many persons at least), in having diuretic properties, and this difference may possibly be one means of accounting for the difference of its action; for, as hinted in a former page, there are some grounds for supposing that the occurrence of convulsion or spasm is greatly favoured by anything which will tend to empty the blood-vessels of their contents. In the same way the diuretic properties of gin may possibly explain why that spirit (as is well known) is so very inferior to brandy in the power of relieving spasm; and if so, then it is more easy to comprehend the problem under consideration,—for if brandy and gin should act differently in spite of the identity of the alcohol contained in them, it is easy to understand that coffee and tea may have a different action in spite of the identity of caffeine and theine. But be the explanation what it may, the practical fact remains and must be attended to; for though it may be of little moment to a person in health whether he delectates upon a cup of coffee or a cup of tea, or whether he prefers a glass of brandy and water or a glass of gin and water, it may be a very different matter to an invalid, and the successful issue of the case may even depend upon the attention which is paid to points of

* Southey's 'Correspondence,' vol. iv, p. 300.

such seeming triviality as the choice of coffee and brandy in preference to tea and gin.

There is little or no question as to the necessity of ordering the habits in such a way as to save the strength as much as possible. There is no question as to the advisability of celibacy. There is no question as to the inadvisability of taxing the brain by any severe study. But there is a question as to the correctness of the rule which is usually laid down with regard to bodily exercise. Arguing from the great readiness with which the muscles are fatigued and the very marked slowness of the reparative process after fatigue, the natural conclusion appears to be that they ought to be *rested* rather than exercised; and experience confirms this conclusion. Often, indeed, I have found a patient to improve in a marked and unmistakeable manner as soon as he had had the resolution to conquer the fidgetiness which is invariably connected with debility, and to force himself to rest; and often I have known a patient begin to retrograde if he had begun to try his strength too soon. Only the other day I had a note from a medical gentleman, in which he told me that a patient about whom he had consulted me, had gone on very well so long as he had made a point of riding to his place of business, and that the fits had returned as soon as he had begun to disregard this direction.

2. The remedies which are found to be most serviceable in epilepsy are such as might be anticipated from the premises.

The results of venesection in epilepsy are by no means

such as to recommend a continuance of this kind of practice; and every one who has had personal experience in the matter, or who has made himself acquainted with the published experience of others, will readily concede this point. It is hard, also, to understand,—now that the circulation is an established fact,—how local depletion should be advisable if general depletion is inadvisable; and this the more, as there is every reason to believe that periodical fluctuation in the circulation and congestion in the head and elsewhere, are only so many direct evidences of simple debility.

The results of the employment of purgatives as purgatives are as unsatisfactory as those which follow upon bleeding or leeching; and this is as might be expected. There is indeed no plethora to call for such evacuation; and there is a special objection against it in the fact that the fits are usually aggravated during the attacks of diarrhœa which are not unfrequent in long-standing cases of epilepsy. Even aperients must be warm and aromatic or they cause much depression and distress.

Tonics, on the other hand, have stood the test of experience, and the evidence in their favour has gone on accumulating continually. Many have been tried but none have been found to be so deserving of confidence as quinine or iron, particularly when they are given in combination with certain remedies which will be mentioned presently. The ammonio-sulphate of copper, the nitrate of silver, and the oxyde of zinc have also their advocates, but I have never been able to satisfy myself that these remedies are to be compared in value with

quinine or iron. Herpin, who is one of the most recent writers on the subject of epilepsy, is very much in favour of the oxyde of zinc, and he says that he cured twenty-six out of thirty-one cases by it, but I am not able to corroborate his eulogium by my own experience in the matter.

The remedy, however, which stands foremost among the remedies which have rendered unequivocal service in epilepsy, is turpentine, and this fact furnishes an argument that dependence will have to be placed on stimulants, for on paying attention to the mode in which an epileptic is affected by turpentine it is certain that the stimulant effects are more prominent than any other. Notwithstanding the evidences in its favour, however, the nauseous taste of the remedy and the irritation which it excites in the urinary and generative organs have always been a serious objection to its use, and the result has been that comparatively few patients have had the resolution to persevere in taking it as long as was necessary for the insurance of permanent benefit.

Under these circumstances, it appeared to me that naphtha might possibly be substituted for turpentine, and so it proved. In doses of half a drachm to a drachm it produced the same decided relief as the turpentine; but it was scarcely less disagreeable, and patients could not be induced to take it for any length of time.

After this it occurred to me to try camphor, and this I did in doses of two or three grains, either alone or in combination with quinine or iron, one or both, according to circumstances. Being given in the form of pills it was free

from the principal objection applying to the two former stimulants, and it had this peculiar advantage that instead of irritating the urinary and generative organs like turpentine, it exercised, or seemed to exercise, a direct quieting influence upon them. In other respects, as tried in several cases, the result was not less satisfactory.

Next in order of time I gave a fair trial to chloric ether, and still with very decided benefit. Under ordinary circumstances I gave half-drachm doses of this preparation, either alone or in combination with the ammonio-citrate of iron, or quinine, or naphtha, and in all cases it proved to be a very favorite and effective remedy, particularly with children. Sometimes I substituted Hoffmann's anodyne in place of the chloric ether; and sometimes, when the need of a stimulant has seemed to be very urgent, I have associated the two; but it has always seemed that this form of ether is far less pleasant and efficacious than chloric ether.

In cases where, and at times when, an occasional stimulant effect was necessary, I have recommended the aromatic spirit of ammonia, either alone or in combination with ether, and the result has usually been certain and satisfactory.

Besides the stimulants which act from within there are others which act from without, and of these the most important and approved are counter-irritants and the hot-bath.

The verdict of past experience is very much in favour of counter-irritants, and this verdict recommends itself

to the judgment, though on different grounds to those on which it is given. Indeed, after the preceding remarks on epilepsy and the cognate disorders, it is not easy to believe that counter-irritants do good by diverting irritation from a vital or important organ; but it is very easy to believe that they may do good by exciting inflammation. It is very easy to believe this, because the fits of epilepsy are frequently suspended by inflammation arising from injuries inflicted during the fits or by idiopathic inflammation, and because all tremulous, convulsive, and spasmodic disorders are suspended under similar circumstances. Inflammation of the brain, for example, puts an end to the trembling of delirium tremens; the cutaneous inflammation of small-pox puts an end to the convulsions of the initial state of collapse; and inflammation of the lungs or air-passages puts an end to the laryngeal spasm of hooping-cough. It is easy to believe, therefore, that counter-irritants may be beneficial in epilepsy, and particularly those kinds of counter-irritants which excite inflammation without producing any exhausting discharge, but I cannot speak from experience, because I have not yet been able to decide upon the best locality for exciting the artificial inflammation.

The verdict of past experience is also in favour of *hot* baths, and with good reason. Indeed, so convinced am I of their utility, that I invariably try to persuade the rich epileptic to have a hot-bath fitted up in his house, if he has not such a convenience already; and for the same reason I do not fail to urge on the poor epileptic the

desirability of availing himself as often as he can of the advantages presented to him in the public baths and washhouses. If the circumstances are favorable, I recommend a hot bath every day, and an additional one whenever any unusual depression leads to the apprehension of a fit; and I have now seen many instances of marked and decided benefit from the adoption of this practice. This plan seems to be equally desirable in long standing cases where there is much cerebral congestion, and theoretically and practically there is much reason to believe that this is what might be expected, especially if a towel dipped in cold water be wrapped around the head of the patient while he remains in the hot-bath.

In actual practice I have rung changes upon these different stimulants, either giving them alone or combining them with iron or quinine, substituting one for another according to the changing circumstances of the case, and always allowing at the same time a liberal supply of dietetic stimulants — upon which, indeed, hope is mainly to be based—and I have had every reason to be satisfied with the results. I have never met with a patient who has not been benefited,—for even where the case has been of long standing and the fits have kept their ground, there has been a manifest diminution of intellectual torpor, the face has lost a good deal of the brutalised expression which had been creeping over it, and the distressing nervous headache has disappeared, if that symptom had been present,—and I have met with many patients who have been completely cured.

If there is one time more than another when stimulants are necessary it is on the eve of the fit. Then, vigorously administered, they will often prevent the paroxysm. Nor are they contra-indicated in the fit itself. At this time, all that is usually required is to raise the head as much as possible, so that the blood may not gravitate into it, and to unloose the neckerchief and shirt-band; but if more is required, it is still upon stimulants that dependence must be placed, and this equally whether the circulation be in a syncopal or asphyxial state. Indeed, under these circumstances the proper course is to dip a door-key or hammer head into boiling water and apply it to the pit of the stomach, or to put the patient into a hot bath, or to take advantage of a moment of quiet and inject a turpentine enema into the rectum. Nor are stimulants contra-indicated after the fit, except perhaps during the first few moments of the reaction which follows upon the collapse, and this only in some instances, for often this reaction is not up to the normal standard. Nay, they are not necessarily contra-indicated by the mental excitement which occasionally supervenes upon the fit, for this excitement is usually, if not always, of an asthenic character.

All these considerations are in harmony with what might be gathered from a simple inspection of the state of the pulse (the true key to practice), and the conclusion is that stimulants will be found to be the proper remedies for epilepsy, if they are given with discrimination and regulated in quantity according to the heat or coldness of the season.

Among the other remedies for epilepsy it is only

necessary to mention the cotyledon umbilicus and tracheotomy.

With regard to cotyledon umbilicus, it need only be said that there is nothing in experience, and less in the simple itself, to warrant any hope, except that which arises from the exercise of the imagination of the patient. Epilepsy requires a stronger spell than an article which might be an ingredient in a salad. It may be coerced by altering the law of life, and by calling in the aid of everything which can rouse the flagging energy of the vital powers, but not by inclining towards vegetarian habits. It is true that the cotyledon was tried by the late Dr. Graves of Dublin, and that he speaks somewhat in its favour; but it failed in three of the six cases in which he tried it, it did doubtful service in the fourth, and in the remaining two it is by no means certain that it did the good which Dr. Graves is inclined to suppose.*

With regard to tracheotomy it is less easy to come to an opinion, and this the more as there is an insufficiency of evidence on the subject. Still it is clear that it does not fulfil all the original expectations of Dr. Marshall Hall concerning it. It does not prevent convulsion. It does not always, or even usually, make the convulsion slighter. It does not prevent danger, for of the few patients upon whom the operation has been performed three have died either in the fit or in connexion with the fit, and of the three, the opening in the windpipe was free from all obstruction—at least in one. Under these circumstances it becomes a question

* 'Dublin Quarterly Journal of Medical Science,' November, 1852.

whether the benefits of the operation are sufficient to counterbalance the associated inconveniences and dangers, even where (which rarely happens) the asphyxial symptoms are consequent upon spasmodic closure of the larynx,— and this question must remain in abeyance for the present.

— As to the rest, it only remains to be said that the accustomed rules of treatment must be applied to the correction of any special sources of exhaustion, and particularly of those which are peculiar to female epileptics.

2. *Of the Treatment of Affections allied to Epilepsy.*

In investigating the mode of cure in these affections it is desirable to follow the plan pursued in the former part of this chapter, and to consider, first, the matters relating to diet and conduct, and then to pass to those which relate to the use of medicines.

1. In tremulous disorders abstinence forms no part of the treatment. A person who trembles habitually, whether young or old, trembles more before a good meal than after it. In chorea it is still the same. Occurring in poor persons there is little or no reason to doubt that the want of a sufficient quantity of nutritious food is a main impediment in the way of recovery. I had lately a patient in the hospital, and I had another about six months ago, who made little progress as outpatients, but who improved immediately and were soon well, without any change in the medical treatment, after they

were taken into the wards, and supplied with necessary food. In delirium tremens and in subsultus, nourishment is of more importance than medicine; and in mercurial trembling the agitation is always worse during fasting. Abstinence, therefore, may be said to form no part of the treatment in tremulous disorders.

There are some facts, also, which seem to show that excess in the matter of food has had no part in inducing the convulsive affections allied to epilepsy. On the contrary, the appetite is always defective in hysteria, and the trouble is to get the patient to eat. Ill-conditioned and ill-nourished children are certainly more liable to convulsion than others. The fact, also, that true plethora is never met with in any kind of convulsion, and that vascular excitement is equally absent, is a strong argument that full-feeding has had no part in the business.

Full-feeding, again, cannot be supposed to have been concerned in the causation of spasmodic disorders. The obstinacy of the laryngeal spasm in hooping cough is in direct relation to the debility of the patient. The corpse-like appearance of catalepsy is wholly inconsistent with the idea that gluttony has been a cause of the disorder. Tetanus, likewise, in spite of all prejudices to the contrary, is now admitted to require the most assiduous administration of nutriment.

In a word, there is no reason to believe that full-feeding has been the cause of any tremulous, convulsive, or spasmodic disorder, and there is much evidence to the contrary.

— The question of stimulants is more complicated, but there need not be much obscurity about the answer if common attention be paid to it.

A glass of wine will quiet an ordinary attack of trembling. A glass of wine will cut short a slight paroxysm of chorea, and will relieve the worst. In this complaint wine and beer are almost as essential to the cure as good food. I have more than once seen a patient rendered calm by a glass of wine, and enabled to speak and stand pretty still, who before was altogether without the power of self-mastery. Wine steadies the hand in delirium tremens, and with equal certainty it calms the trembling heart and the twitching limb in the last stage of fever. It is also well known that a stimulant of one kind or another will put an end for the time to mercurial trembling, and enable the subject of this disorder to go on with his work without much difficulty.

The propriety or impropriety of stimulants in the convulsive affections which are allied to epilepsy will be best considered when speaking upon remedial stimulants; but in the meantime it may be said that the impending or actual failure of the circulation, which is always present during the fit, is, to say the least, an argument in their favour, rather than against them. It is to be remembered, also, that a glass of wine is the established domestic resource in the commotion which ends in hysterical convulsion, and that it is an admirable specific under these circumstances.

In spasm the great body of evidence is in favour of stimulants. Wine is invaluable in the spasmodic stage

of hooping cough. A warm night-cap is a well-recognised specific against nocturnal cramps in the legs. Brandy and water does not fail to dispel the cramps of *incipient* cholera; and if brandy and wine were withheld in the majority of cases of tetanus, there can be no doubt that the patient would sink and die with great rapidity.

In many of these disorders there appears to be the same objection to tea which existed in epilepsy. It is certainly not the most desirable beverage for persons who are apt to tremble; nor does it agree with the subjects of chorea or mercurial trembling. It often seems to favour, if not to induce, hysterical troubles; and great tea drinkers are so often the subjects of pain and spasm, in one form or another, that it is difficult to suppose that tea has nothing to do with the matter. Coffee, on the other hand, appears to act beneficially in all cases.

— In chronic cases where such a question can arise, there can be no doubt as to the expediency of *rest*. It is well known how ordinary trembling is aggravated by fatigue. In chorea, also, a most important means of promoting recovery is to economise the strength by keeping the patient in bed for a few days.

— In all cases, also, where any such question can be entertained, there can be no doubt that all severe study is undesirable. It is of much importance that this should be attended to in all cases, but particularly in children; and there is reason to believe that owing to the neglect of this precaution epilepsy has very frequently become grafted on the convulsions of early life.

So far, therefore, the rules which applied to epilepsy apply also to the cognate disorders, and generous living and rest are still found to be essential. In the same way the strength must be economised, and in the same way the vital powers must be roused and invigorated.

2. These conclusions with respect to diet and conduct are borne out by the results of medical treatment, and stimulants and tonics are still the only remedies upon which any just confidence can be placed.

— There are no advantages arising from depletion, whether by abstraction of blood or by purgatives, which can be urged against the opposite kind of treatment.

The results of experience in bloodletting do not set aside the fundamental objections to the practice which arise out of the pathology of these disorders. There are cases which have tolerated depletion by this means; there are others which have become greatly aggravated, and apparently for no other reason; but there are none in which benefit can be shown to have resulted according to any exact system of logical inquiry.

The same remarks apply to purgatives. Aperients may be necessary; anthelmintics may be necessary; but purgatives as purgatives give rise to much distress and depression without any corresponding benefit, and this fact is now very generally beginning to be suspected.

— There are no advantages arising from the use of opium, indian-hemp, tobacco, or hydrocyanic acid, which can be urged against the use of stimulants. All these remedies have been abundantly tried, and all have failed to justify the hopes which had been reposed in them.

— Tonics do not appear to be necessary, except now and then in such chronic cases as chorea, hysteria, or catalepsy, or in such states of convalescence as follow after tetanus. In these cases, and under these circumstances, quinine and iron will probably be found to be the most valuable of this class of remedies.

— Stimulants, on the other hand, appear to be as indispensable as they are in epilepsy.

In ordinary tremulousness sal volatile or ether are admitted remedies; and so are they in delirium tremens, in subsultus, and in mercurial trembling. In chorea I am in the constant habit of giving large doses of chloric ether in conjunction with the ammonio-citrate of iron, and I can speak very positively as to the benefits resulting from this practice.

Nor is there any reason to believe that epileptiform convulsion must not be treated upon the same general principles as epilepsy.

When the skin is pale and cool, and the pulse miserable,—when, in fact, the circulation is in a syncopal state, there can be little doubt as to the necessity of stimulants. In such a case, the hot bath and the turpentine enema are the admitted and natural means for rousing the fainting heart and pulse.

When, on the other hand, asphyxial symptoms are predominant, the first impulse may be to unload the congested veins by making an opening into them, but on second thoughts it seems as natural to aim at bringing about the same result by rousing the heart and capillaries to their proper action. Nay, it is more

natural to do this, for the cool hands and feet, and the miserable pulse in the wrists and ankles, are sufficient proofs that blood is wanted in the limbs. Hence it may be argued that stimulants are still the natural remedies, and that the proper course to be pursued is to endeavour to restore the circulation by the application of hot metal to the pit of the stomach or over the heart, by hot fomentations to the hands and feet, by the hot bath, by the injection of hot and stimulating enemata, and by other and similar means. It may also be argued that all this may be done without any regard to the state of the brain, except so far as to be more careful to apply heat to the extremities when there is reason to believe that this organ is specially affected. Under these circumstances it may or may not be necessary to apply cold to the head after the fit; but as a rule the fears of subsequent reaction are very much exaggerated, and the difficulty will be found to be, not to subdue unusual action, but to preserve ordinary action. It appears, therefore, that the same rule of treatment must be observed whether the convulsion be accompanied by asphyxial or by syncopal symptoms; and this being the case, the same rule which applies to the treatment of epilepsy applies also to the treatment of epileptiform convulsions, for all these convulsions are accompanied by asphyxial or by syncopal symptoms. Nor do I know of anything in clinical experience which is in any degree opposed to these considerations. On the contrary, all that I have myself seen is in perfect harmony with them.

I have not had an opportunity of carrying out these principles in hydrophobia; but if I had I would do so without any hesitation. I would give frequent draughts of ether and hot brandy and water, along with turpentine injections; and if the act of swallowing was very distressing, I would multiply the injections and administer the ether and brandy in this manner. I should be prepared to act patiently and vigorously, as knowing how large a quantity of stimulus is necessary to rouse a patient from any serious collapse, and particularly from that caused by an animal poison—if any argument is to be derived from the history of snake bites and dissecting wounds.

The same rules of treatment apply to spasmodic disorders. In obstinate spasm the necessity of stimulants is an established fact. In the spasmodic stage of hooping cough I can testify as to the great benefit resulting from large doses of chloric ether, along with steel or camphor mixture, according as the patient was anæmiate or not. In catalepsy and tetanus it is not so easy to speak from personal experience, but it has fallen to my lot to have to treat a case of catalepsy and a case of slight tetanus, and in both instances the spasms were almost immediately dispelled by the vigorous use of brandy and chloric ether. In the latter disorder, however, a great change in opinion has already taken place, and it is now very generally admitted that stimulants are not to be dispensed with in the treatment.

Still, even in tetanus, the influence of stimulants has yet to be fairly tested. These remedies must not be given

doubtingly, after depleting measures have been tried, or in conjunction with such measures, as has been the case hitherto; but they must be given at the beginning, and steadily persevered in until the spasm relaxes, even though large quantities have to be expended in the process. And, if unfortunately the collapse has been permitted to gain ground, they must be given, as he only is properly prepared to understand who has seen for himself the very small effects which they produce under these circumstances.

Nor have stimulants been tried as they ought to be tried in cholera, if the cramps of this disorder require to be treated according to the rules laid down in these pages. Acting according to these rules, the patient should be placed in a *hot* bath, and then plied with glass after glass of iced port wine, or of iced brandy and water, until the cramps relax and the system rallies; and reasoning from the results which have followed the carrying out of these rules in other states of spasm or convulsion, there are some grounds for hoping that the prompt and vigorous adoption of these means would disarm cholera of its cramps, if not of its remaining terrors. And these grounds for hope would be increased if trust was placed upon wine and brandy, which might be taken with satisfaction, rather than upon ether or any medicinal stimulant, which might do harm by increasing the nausea and sickness.

The previous conclusions respecting stimulants are not at all invalidated by the fact that the spasms of tetanus and the convulsions of hydrophobia and of some other

disorders may be suspended for the time by the inhalation of ether or chloroform. On the contrary, this fact furnishes another argument in favour of this conclusion, for, *so far as the muscles are concerned,* these inhalations act by the stimulation which they produce. Like wine, ether and chloroform excite if given in small quantities, and stupefy if given in excess; and the same analogy holds good when the system is fully under their influence, for then the muscles are relaxed, and the whole condition is similar to that of the person who is dead-drunk from ordinary causes. Under all circumstances the muscles are relaxed (even in mortal extremity the main cause of death appears to be that the heart and the respiratory muscles are so relaxed that they cannot enter with sufficient readiness and rapidity into the state of contraction), —and being relaxed, the inference is that the muscles have been stimulated, for according to the principles which are laid down in the previous pages, the muscles are most stimulated when they are most removed from the contracted state.

The fact, therefore, that spasm and convulsion are relaxed during the inhalation of ether or chloroform is only another proof that stimulants are the proper remedies for the disorders under consideration. It adds confirmation to the previous conclusions, and at the same time it suggests a mode of employing stimulants which is likely to be of great advantage in many cases, particularly if the inhalation be associated with, and made subordinate to, the administration of stimulants whose effects are less transitory than those of ether or chloroform.

— In connexion with tetanus and spasmodic cholera, the presence of pain suggests the use of opium, and this suggestion has been fully carried out; but the results of the trial do not appear to set aside the objections which naturally arise out of the anti-stimulant properties of the drug. There is also some reason to believe that the pain in these cases is similar to the pain in common cramp, and this analogy points to stimulants rather than to opiates, for stimulants have been proved to be the natural and appropriate remedies in common cramp. Opium may be of great value in delirium tremens, and in some other cases when mental agitation is the predominant symptom; but, arguing from existing evidence, it does not appear to be indicated *in* cases of tremor, convulsion or spasm, *as* cases of tremor, convulsion or spasm.

— The special circumstances which arise in connexion with the disorders which have been under consideration, will have to be met by special means. In hysterical convulsion it will be necessary to apply common rules to the suppression of exhausting uterine discharges. In the tremor, convulsion, or spasm which are caused by the slow introduction of lead into the system, it may be well to put in practice the elegant treatment which has been recently recommended by M. Melsens, and endeavour to liberate the poisonous metals from the tissues with which they had entered into combination by favouring the formation of a new and soluble compound between them and iodide of potassium, which compound is found to be eliminated from the blood by the kidneys

when the iodine-salt is given as medicine. When there is laryngismus it may be necessary to consider the question of tracheotomy, but such a necessity will but rarely happen. This and any other incidental question must be decided upon general and admitted rules.

It appears, therefore,—as was anticipated from the premises—that epilepsy and the cognate disorders must be treated upon the same principles, and that upon these principles every cause of depression and exhaustion must be avoided, every means of increasing and establishing the strength must be sought after, and stimulants must be trusted to as the grand agents in recovery. In a word, physiology, pathology, and therapeutics concur in showing the necessity of a complete revolution in everything relating to the theory and practice of the maladies which have been under consideration, and they also justify the hope that in future the theory will not be a subject of mystery, or the practice a source of conjecture, perplexity, and failure.

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