

The electro-physiology of man : with practical illustrations of new and efficient modes of galvanic treatment in a variety of cases / by John Doddridge Humphreys.

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Publication/Creation

London : William Pickering, 1843.

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LECTURES ON THE

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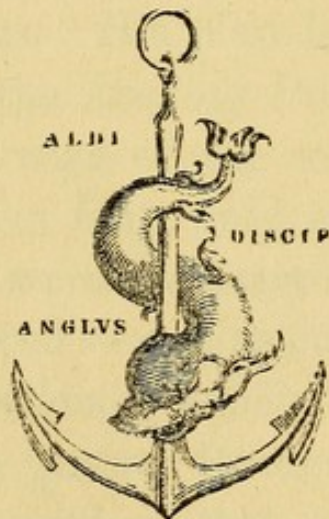
ELECTRO-PHYSIOLOGY

OF MAN

THE
ELECTRO-PHYSIOLOGY
OF MAN.

WITH PRACTICAL ILLUSTRATIONS OF NEW AND EFFICIENT
MODES OF GALVANIC TREATMENT IN A
VARIETY OF CASES.

BY
JOHN DODDRIDGE HUMPHREYS, ESQ.



LONDON:
WILLIAM PICKERING
MDCCCXLIII

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PREFACE.

IN laying these pages before the Public, the Author has only to express his ardent desire that they may be useful; and to explain that, with this object constantly in view as the beacon of his course, he has avoided technicalities, extraneous speculations, and the arbitrary trammels of artificial systems. His plan has therefore been, to show the *Leading Principles* and *Practical Bearings* of the subject, in a simple and direct form, only entering into such details as were necessary to prove the premises advanced:—and as many original views are entertained which may be interesting to the general Reader, a familiar style has been used, as that which would be most extensively understood.

Under the same views, the materials have been carefully condensed; and a mass of scientific details, of a secondary interest as

collateral proofs, has been reserved, as it would have occupied a much larger space than the plan of the present publication would admit of.

It may be remarked, that almost every man of distinguished talent who has written on Physical Science, has foreseen the inseparable connexion of Electricity with Physiology. Thus to M. de la Rive belongs the honour of having referred the phenomenon of Animal Heat to this agent; and M. Prevost has shown, by a beautiful experiment, that steel may be magnetized by nervous influence. And again, Professor Faraday, in speaking of Electricity as "the most extraordinary and universal power in nature," goes on to say, that—"It is probable that every effect depending upon the powers of inorganic matter, and perhaps most of those related to vegetable and animal Life, will ultimately be found subordinate to it."

In conclusion, the Author would observe, that he hopes the day is not far distant when it will be felt that every man of general information should possess some solid views of the outlines of PHYSIOLOGY,

as a science not only valuable to himself and family for the preservation of health and comfort, but as essential to the discharge of his duties as a member of society at large ; for there are many points of domestic policy where its influence would be of vital importance, as enforcing such regulations as the ordinations of Providence have rendered indispensable to the well-being of man, and which do not bear infraction without the most pernicious results ;—without, for instance, such fearful and melancholy consequences as the present deplorable state of our closely populated districts presents ; or the long catalogue of practical evils,—life-consuming and torturing inflictions, which the Official Investigations into the state of our *Prison Discipline* have laid before the world.

JOHN DODDRIDGE HUMPHREYS,

Medical Galvanist.

10, John Street, Pentonville,
February, 1843.

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THE ELECTRO-PHYSIOLOGY OF MAN.

CHAPTER I.

EARLY USE OF ELECTRICITY AS A MEDICAL AGENT: ITS INFLUENCE ON THE VITAL FUNCTIONS: THE WANT OF SCIENTIFIC DATA FOR ITS SUCCESSFUL EMPLOYMENT HAS PREVENTED ITS BEING BETTER KNOWN AS A REMEDY.—IMPROVEMENTS OFTEN VIEWED AS INNOVATIONS.—VARIED RESULTS FROM DIFFERENT FORMS OF ELECTRICITY. PRACTICE MUST BE FOUNDED ON PRINCIPLE.—SOME OF THE LEADING ATTRIBUTES OF ELECTRICITY, AND THEIR RECIPROCAL AGENCY WITH THE PHENOMENA OF LIFE, VIEWED AS THE PROPER GROUNDS FOR THE STUDY OF ELECTRO-PHYSIOLOGY.—OF THE ACCUMULATION OF ELECTRO-FORCE IN THE HUMAN BODY.

IN a former treatise I expressed the conviction that Voltaic Electricity would ultimately be found to exert an influence as commanding over medical science, as that of the Steam-Engine in mechanics. And already so far beyond my hope has this prediction been verified, that the power of this agent, as a remedy in some

of the most hopeless forms of disease, has been publicly attested at Guy's Hospital; while I have before me evidence of its efficacy in patients of my own, whose cases were incapable of relief from the ordinary resources of medical aid, and who had previously consulted some of the leading physicians of this country and of the continent in vain.

From the birth of the science, Electricity has attracted the attention of many of the first practical philosophers of Europe, and its early dawn could boast of a Franklin and a Priestley; of these, the latter, with an almost prophetic sagacity, in 1774 pronounced it to be the agent of muscular motion; and its connexion with the phenomena of life appeared so evident to all, that its employment in medicine was of a still more early date, as in 1744 a woman was cured of a contracted finger in a quarter of an hour by M. Kratzentein at Hale. Other instances of its salutary power followed in the practice of the continental physicians; and in 1762 a signal instance of its influence in Chorea occurred to Dr. Watson, which is thus related in the *Philosophical Transactions of the Royal Society*, vol. liii. p. 10: "The patient at about seven years of age was seized with a universal rigidity of her muscles, so that her whole body felt more

like that of a dead corpse than a living person. Dr. Watson electrified her at convenient intervals from the middle of November 1762, to the end of January 1763, when every muscle of her body was perfectly flexible and subservient to her will, so that she could stand, walk, or run, like other children." Mr. Hey too, the celebrated surgeon of Leeds, mentioned several instances in which he had found Electricity successful in Amaurosis in vol. v. p. 18. of the Medical Observations.

Still more striking were the results obtained from the Galvanic form of Electricity.

Professor Rossi of Turin, beyond all question, cured a case of Hydrophobia. Galvani, Volta, Aldini, Vassalli Eandi, Humboldt, and many more were successful in other diseases; while in this country, much was done by Dr. Wilkinson, the well known author of the Elements of Galvanism, who has the following passage:

"Galvanism appears to be an energizing principle, which forms the line of distinction between matter and spirit, constituting in the great chain of the creation the intervening link between corporeal substance and the essence of vitality."

To Dr. Wilson Philip was, however, reserved the distinguished honour of proving by actual experiment that a current of Voltaic Electricity

carried through a nerve which has been severed from its connexion with the brain is capable of supporting the functions of Respiration and of Digestion;—that when “applied under the same circumstances, as the Nervous Energy,” or as others would say, to stimulate its dormant powers—“it is capable of all its functions; of exciting the muscles; of causing an evolution of caloric from arterial blood; of forming from the blood the various secreted fluids; and of maintaining all the other processes of assimilation, on which the healthy structure of every part depends.”

This great experiment was carefully tested by the Royal Society before its publication in their Transactions; it was afterwards repeated and verified by the Academy at Paris, and it is now admitted in all the Medical Schools of Europe.

Under these circumstances the question naturally arises, and it is one of great moment, both as it regards the welfare of the public, and the honour of the profession: How is it, that a remedy so all commanding, and so truly philosophical, is not universally employed? And above all, how is it, that the science of Electro-Physiology is not taught in our Medical Schools? The answer would simply be, that *its abuse has prevented its use!* Medical men, not having

been taught the principles of the science, and not having had time to investigate the subject in later life, have operated with the inefficient electro-magnetic machines of the shops; or, at best, with small batteries, or electrical machines, which are all no better than the playthings of a child, and only fit to illustrate a course of natural philosophy at a lady's boarding school. But, even worse than this, some men of eminence, from a theoretical view of the subject, have led themselves and others into practical mistakes.

An explanation of these erroneous views is indispensable; but it may be well, in the first instance, to place the Reader on the solid ground of our subject before we uncover the pitfalls from which it is our duty to guard him. Thus Dr. Wilson Philip in his *Investigations into the Laws of the Vital Functions*, published the fact, that it was only by Voltaic Electricity that the effects on the organs of respiration and digestion could be produced; the results with the electrical machine being very feeble and unsatisfactory. The marked difference between the Galvanic form of Electricity and that of Friction is also shown by Fowler, who states, "It is a well known fact that Electricity exhausts irritability" in the muscular fibre, "which Galvanism, on the contrary, seems to augment."

Dr. Wilson Philip ascribes the superior efficacy of Galvanism to its superior chemical power, which is not only infinitely greater, but different in its character, as in the decomposition of water by the electricity of the machine, both gases are given off at the same conductor, while with the galvanic poles, the oxygen appears at the positive, and the hydrogen at the negative. Dr. Ritchie states that "voltaic electricity exists within the metal, free electricity over the surface," and that "the *supposed analogy* between common, and voltaic electricity, which was so eagerly traced after the invention of the pile, completely fails in this instance, which was thought to afford the most striking resemblance." —Phil. Trans. for 1832, p. 279. Dr. Roget too, points out a signal difference: "We have seen that charcoal is very readily ignited by galvanism, but it will sustain a strong discharge from an electrical battery without any perceptible rise in its temperature, nor is it possible to ignite it by this means. Whether reduced to a fine powder, or cut into thin plates, or made taper to a point, it resists all attempts to raise it to a red heat, or even to impart to it any sensible warmth, though subjected to the action of the most powerful battery that has yet been tried."

Dr. Henry, of Manchester, states that "the oxygenous gases are rapidly diminished by electrical discharges, but not by the passage of the galvanic fluid." Dr. Davy remarks, "May we not suppose, according to the analogy of the solar ray, that the electrical power, whether excited by the common machine, or by the voltaic battery, or by the torpedo, is not a single power, but a combination of powers, which may occur variously assimilated, and produce all the varieties of electricity with which we are acquainted."—Phil. Trans. for 1832, p. 259.

I have thought it the more necessary to explain the practical differences existing between different forms of electrical excitement, both as to chemical character and physical influence, as Dr. Golding Bird, to whom a great debt of gratitude is due for the public demonstration of the efficacy of electricity in the Medical Practice at Guy's Hospital, has unluckily made himself a champion of the theory of their identity to an extent which has evidently circumscribed that practice to an injurious degree.

Dr. Bird writes as follows, "Electricity and Galvanism, it must be borne in mind, are but different names for one and the same agent, the *only real difference* being, that in the electricity of the common electrical machine we have the

peculiar imponderable matter in *small quantity*, but in a state of *high tension* or elasticity; while in that of the galvanic battery we obtain it in *enormous quantities*, but in a state of *low tension*: so that the real distinction between electricity and galvanism may be familiarly stated thus, that whilst in both we have the very same form of matter, in the former we have a small quantity very concentrated, in the latter a much larger proportion in a dilate form."

A single candid confession will cut this Gordian knot at once; of the chemical nature of the agent, or agents, *per se*, we know absolutely nothing; we cannot analyze them, and can only judge of them by the effects which they produce; and these, as seen in the forms of common electricity and of galvanism, are so widely different, as shown by the authorities already quoted, that for physiological purposes it is desirable to separate them as far as possible; for instance, Dr. Wilson Philip gained his great results by the continuous stream of a galvanic battery of great chemical power, while the forms used at Guy's were sparks from the machine, shocks from the jar, and from the fine wire of an electro-magnetic helix, which in either instance have scarcely any chemical agency, and consequently we hear nothing from Dr. Bird of

the commanding influence of voltaic electricity in cases of impeded respiration, or of an augmented energy in the digestive functions of the stomach, or of the free evacuations of bile mentioned by Dr. Wilson Philip: nor does he relate any instances of renewed growth in limbs previously withered by paralysis, or of the signal increase of weight in other cases, which has occurred in my own practice.

These particulars may show the necessity which exists for the task I have proposed to attempt in these pages;—that of explaining and tracing out, as far as the present state of science admits, the physiological laws of the remedy in question; for very strangely, and even up to the present moment, all parties have been at sea as to Medical Electricity, and that, indeed, without either chart or compass.

Dr. Golding Bird observes, “So many discrepant statements exist in the records of medicine, regarding the action of electricity as an agent in the treatment of disease, that scarcely any general opinion can be drawn regarding its real influence. In the hands of some it has appeared to possess an almost magical action in the most intractable diseases, whilst others equally worthy of confidence have declared it to be utterly useless.”

Such, undoubtedly, has been the fact; but when properly understood, the discrepancy merely amounts to this,—that both statements were equally correct, both parties used Electricity, but the one succeeded and the other failed, simply because the form, mode, and power of the applications were right in the one instance,—and wrong in the other. How indispensable is it then, that the general principles of this science should assume the form of practical arrangement; but here, it must be confessed, that had it not been for the comparatively recent investigations of Davy, of Oersted, Ampère, Barlow, Faraday, Daniell, Crosse, Harris, Cumming, Seebeck, and other men of talent, into the physical laws of Electricity, our physiological results would have been but very meagre and unsatisfactory.

This recent growth of the science explains the reason why so little is known of Electro-Physiology by the leading practitioners of the day. Their great engagements have not left them time for its due investigation. My professional education had placed me on intimate terms with some of these, who, when I devoted my attention to this new study, very candidly admitted the fact; and several others to whom I was then introduced made the same admission,

and did me the honour of expressing their satisfaction at my having entered on "this uncultivated field of medical inquiry." Of these, one of the most distinguished physiologists in Europe, Dr. Marshall Hall, expressed a deep interest in the proposed researches, and predicted that the influence of Electricity on the secreting organs would be found important. To many other celebrated men I have been equally indebted; and I am glad to have this public opportunity, of bearing testimony to the love of science shown by Dr. Burne, and Dr. Hamilton Rowe, who desired to place patients at the Westminster Hospital under my care for electrical treatment; I could not, however, avail myself of their offer from the engagements of my private practice. And my best thanks are no less due, to Dr. Samuel Dickson, late Physician on the Staff, for the disinterested, candid, and very handsome manner in which, and at an early date, he transferred patients to me, whose cases required the advantages of galvanic treatment.

It is a pleasing duty to record this liberal course of conduct in the higher grade of the Profession; but it is still of great importance for the Public to understand that, like all other signal improvements in practical medicine, it

must be the fate of Electro-Physiology to encounter opposition from prejudiced and self-interested men: such was the case with that glorious discovery, the Circulation of the Blood, for which Harvey was rewarded by the loss of two thirds of his practice! Another instance occurred at the introduction of Inoculation, which was ridiculed on all sides, from the silent shrug of solemn ignorance, to the broad grin of buffoonery; and even branded as a direct species of scientific homicide. Then again, in the instance of Dr. Jenner and Vaccination, the same system was pursued, and every sort of impediment thrown in his way, until the cause of good sense and humanity triumphed under the sanction of Public Opinion.

So must it be with Electro-Physiology: as Dr. Granville emphatically told me,—it is in vain to lean altogether on professional support; society, at large, must be awakened to a sense of its own interest, and when once the subject is duly understood, its own merit will defend it against sinister attacks. In the meantime, I would caution the Reader, that he must think for himself to a great extent, on this subject, and act accordingly; for it is not very generally to be expected, that his medical attendant will be the first to propose the transfer of a patient;—and as

for electricity in a little way, that is, as it can be administered by a general practitioner, as before observed, it is no better than the plaything of a child. I have had a patient who had been carefully electrified for three months, and by a clever man too, in this *little way*, without a shadow of benefit ; and other instances have occurred of a similar kind. But far worse than these, persons under dangerous circumstances have been deterred from seeking the relief which galvanism might have afforded, until it was too late. One gentleman with slight paralysis, was so deterred day after day, until at last he fell down in his own room, under an irremediable stroke.

But the difficulties have not been all from without ; when preparing for this practice, I soon found, that to realize the advantages that it was capable of bestowing, many modifications of the old, and several new forms of apparatus would be needful ; and these I had to invent for my purpose, with an unavoidable loss of time, and frequently at considerable expense, before the object was obtained. One great desideratum was, to be able to command the requisite power without the occurrence of pain in those instances in which it would have been injurious ; and some idea of the various modes of action to

be obtained from different chemical arrangements may be gathered from the fact so familiarly known with regard to the electrotpe, viz. that under the action of a battery of several cells the metal deposited is of an imperfect and spongy texture, from the mixed effects of *intensity* and *quantity*; while a gentle current from a form of battery giving almost entirely the effects of *quantity*, yields a metallic deposit of a singularly close and beautiful character. It will hardly be questioned, but that the brain, and nerves,—the animal fluids and solids, are as delicately sensible of such varieties of action, as the forms of inanimate matter.

A still more important field for original investigation remained in the fact, that the Electro-Physiology of Man was in the general sense unknown. The effects of electricity on certain organs had been proved; and the electrical condition of certain parts of the human body had been manifested; but no general system of the reciprocal agencies existing between the laws and influence of electricity as a physical power of external nature, and the vital functions essential to animal life, had been sketched out however roughly.

With due submission, I would remark, that without some leading ideas, and general outline

of this nature, no satisfactory data for the employment of Electricity as a medical agent can be hoped for; and that the uncertainty which has existed has been unavoidable. Thus some writers have committed the absurdity of classing Electricity as an external remedy;—others have termed it a stimulating agent; and some have ascribed its influence to counter-irritation, as if a mustard plaster might have had the same effect.

But to the question before us,—the Electro-Physiology of Man; and here it may be desirable in the first instance to enumerate the principal attributes of the electric fluids to be afterwards referred to.

First:—THE SEPARATION OF THE PARTICLES OF SUBSTANCES FROM EACH OTHER WITHOUT CHEMICAL CHANGE. The hardest bodies in nature are instantaneously dissipated into a mere fume or invisible dust when exposed to the action of a galvanic battery of sufficient power. On this principle fluids are enlarged in volume, so that a glass vessel confining mercury is at once shivered; and any liquid flowing through a tube gains an increased velocity.

Secondly:—POWER OF CHEMICAL COMBINATION AND DECOMPOSITION. Under this head, in the general sense, are comprehended

all changes in the conditions of matter arising from what are termed the chemical affinities, and in each of these as far as hitherto explored, the investigations of Davy, Faraday, and others, have shown that Electricity is a leading and inseparable agent. Large quantities of this fluid are evolved during even the most silent and gentle of the vital changes, as in the germination of seeds; and Faraday remarks, that a drop of water yields under decomposition a volume of electricity sufficient to have constituted a flash of lightning.

Thirdly: — ATTRACTION AND REPULSION WITHOUT CHEMICAL CHANGE. These phenomena occur when the quantity of electricity is insufficient to alter the chemical state of the particles acted upon, and are the peculiar attributes of the two separate electricities; each repelling its own kind and attracting the opposite, and each again having, when moving in parallel streams, a self-attractive and repulsive influence in accordance with its magnetic polarity.

Fourthly: — POWER OF IMPELLING FLUIDS THROUGH INTERCEPTING MEDIUMS. Fluids are drawn in certain directions, and accumulated under the attractive, repulsive, and chemical agencies of electricity.

Fifthly:—POWER OF INDUCING MUSCULAR CONTRACTION, AND OF CAUSING AN INCREASED DEVELOPEMENT OF HEAT FROM THE ARTERIAL BLOOD. It is of moment to remember that electricity is not capable of giving the first of these results after the phenomena of death have advanced so far as to extinguish irritability; and the second only when the blood is actually flowing, so that these great attributes are secondary to the Vital Principle.

Sixthly:—LAWS OF ACCUMULATION AND DISPERSION. Under these heads are comprehended the principles of vibration, of induction, and all the modes in which electricity is obtained in a sensible form, as by the chemical action of solids and fluids in galvanic arrangements, in animal assimilation, and by the effects of percussion, friction, and atmospheric pressure.

After this enumeration, the following question may naturally arise:—The direct influence of Electricity on certain vital organs having been proved, and its laws being such as to compromise others, how is it that some systematic plan of Human Electricity has not been traced out? The simple answer would be, that it is only very recently that the great importance of Electricity as a branch of physiological science has been

admitted, while it is to be observed that the splendid success which followed partial investigations, as in the instance of Dr. Wilson Philip, has led many distinguished men into the mistake of confounding Electricity with Vitality itself; hence they have been called upon to explain more than they could prove: and a torrent of empty tirades against the imagined materiality of Vital Electricity has been thrown out by the uninformed and the prejudiced. Another great difficulty has occurred from the impossibility of directing anatomical investigations of any extensive character to the illustration of this subject; it is true that to a certain extent they form its basis, but Electricity as a secondary power is so connected with Life, that after death nothing remains for us to discover; and very fortunately for the best interests of humanity, the exposure of wounded surfaces to the air, and the presence of severe pain, will so totally derange the electrical functions as to defeat the intended researches: in the experiments of Dr. Wilson Philip the animals suffered so slightly as to eat immediately after the section of the nerve had been made; and the results having been publicly proved, do not require to be repeated.

Human Electricity is rather to be learnt from the inferences which unavoidably arise on a contemplation of the reciprocal agencies created by the phenomena of animal life, when acting in conjunction with those which originate in the common electrical laws. Thus, for instance, our first point must be to explain the existence of an accumulation of Electricity, its distribution, partial retention, and means of dissipation.

It is a chemical law that all bodies in the process of combination yield in part, or exchange their relative, positive, or negative electricity; and that in the majority of instances, a surplus, or as it is termed, a residue of "free electricity" is the result. It is the well known object of the function of respiration to effect a combination of the constituents of atmospheric air with the blood; the oxygen is absorbed with a portion of the nitrogen, the rest being thrown off with carbonic acid gas, and water in the form of vapour; and all these changes lead to an extrication of Electricity in the lungs. The air itself, too, has generally a surplus of positive electricity, which is appropriated during respiration; for the experiments of Reid and others have shown that expired air in confined spaces, as close rooms, the wards of hospitals, &c. is de-

cidedly *negative*. Our result then is, that by Respiration the body accumulates Electricity, with a preponderance of the Positive; a fact shown by the uniform Positive Electricity of the Blood.

Next in importance to the function of breathing is that of Digestion; and in the human stomach we have an organ which, under the influence of vitality, is capable of inducing the chemical decomposition of an infinite variety of bodies with a degree of rapidity and power which is truly wonderful: and in each and all of such instances is Electricity evolved, and often in great volume, of which the observation of Faraday on the decomposition of a single drop of water, as already quoted, may convey some slight idea: and again, it should be noted, that the positive form of electricity is the one principally accumulated by this means, as all the excretions are found to be in a negative state of electricity.

It is equally clear that the compression, concussion, friction, and vibration, attendant on the expansion and contraction of the arterial system and on muscular action, with the chemical results from the processes of secretion and assimilation, are all so many means of accumulating

and dispersing Electricity; but as these are phenomena arising within the body, and dependent on its proper Electricity, as acquired in the modes before mentioned, their investigation will more naturally arise under the details of our subject: it is its general outline which we have now to consider.

The extrication of a large volume of Electricity having been shown to be the necessary result of the vital functions, it is self-evident that this electricity must either be an extraneous result, to be got rid of as useless by excretion, or that it must become one of the most commanding agents of animal life. The point is then comprehended in this question:—Is the electricity of the human body retained or immediately thrown off? We have ample testimony that it is retained;—and a moment's reflection will convince us that nothing could be more accordant with that simplicity of means, and that perfection of design, which reveal themselves to our admiration in all the works of the Deity, than such an ordination.

Electricity, we have reason to believe, pervades all space;—of its sublimity and terrific power in the elemental arrangements of external nature, all generations have been sensible; and

this renders it the more striking, to consider, that this flaming minister becomes, under the Divine Wisdom, the gentle agent of our everyday existence.

CHAPTER II.

ORGANIC ARRANGEMENTS FOR THE RETENTION OF ELECTRO-FORCE : VARIOUS HABITS OF MANKIND HAVING THE SAME INFLUENCE.—OF THE EFFECTS OF CLIMATE AND OF OTHER PHYSICAL AGENCIES.—COLLATERAL PROOFS.—CURIOUS AND UNSUSPECTED COINCIDENCE OF SURGICAL PRACTICE WITH ELECTRO-EFFECTS.—PHYSIOLOGICAL INFLUENCE OF THE HAIR.—ELECTRO-PHENOMENA OF THE PASSIONS.—STATES OF THE HAIR IN DISEASE.

OUR next point must be, to learn something of the means by which the due Electricity of the human body is retained, as far as is consistent with its constant circulation, and the gradual expenditure of its surplus. The chief external arrangements for this object are the outward Skin or epidermis, with its peculiar secretions, containing an oily principle, and ammonia, and the Hair, all of which have more or less non-conducting properties. The internal are the unctuous character of the nervous sheaths, and of the tissues enveloping the glands, with the depositions of fat in the cellular membrane, and more particularly about certain of the secreting organs, as the kidneys, the mesentery, &c. ;

and to these must be added, the law of chemical affinity, by which the venous blood, from its carbonaceous character, absorbs and retains the electricity of *quantity*, a term which denotes that form which has the greatest chemical and magnetizing power.

The non-conducting quality of the human Skin is strongly marked, and the dryness on which it depends, is sufficiently preserved by the warmth of the body, and the instinctive habits of avoiding exposure to the damp and wet for any length of time, common to man in every state of society. It is remarkable, too, that the construction of the epidermis is such as to preserve it from being easily saturated with water, in which case alone it constitutes a good conductor; its surface being formed of an infinite number of minute laminæ, or scales, which retain air beneath them: there are also myriads of exhalent orifices, emitting an unctuous, insensible perspiration, with more or less ammoniacal gas; all these particulars being most complete when most required; that is, when man appears in what is termed the savage state, or when inured to a life of toil and exposure.

It being thus an evident object, to retain the electricity of the body by the non-conducting quality of the skin, we may presume that

those habits and circumstances which are most in accordance with this view are most conducive to health and its concomitants, a pleasurable existence and longevity. A very little enquiry will convince us that such is the fact, and even show us that the instinctive habits of our race have, in a variety of instances, been exactly such as a knowledge of the laws of Electricity would have recommended, had the science been discovered. An example occurs in the use of artificial heat by fire, which is highly conducive to electrical retention, both as maintaining the dryness of the skin, and that of the air. The articles of clothing, too, are all, more or less, non-conductors, and some of them very highly so, as the greasy hides, the fur, and the feathers employed by the savage; and the woollen cloth, the cotton fabrics, linens, and silks of civilization. The bedding of man, too, is in all instances in this sense most effective; from the dry grass, straw, skins, and mats of the Indian, to the hair mattress, the feather beds, blankets, and sheets of the European, or the muslin and silken coverings, the velvet cushions, and camel-hair mattresses of the Asiatic. Beds of all sorts constitute, indeed, to all intents and purposes, appliances and apparatus to prevent an undue expenditure of vital Electricity; and the terrible

consequences which sometimes result from their being accidentally in a damp state, are, on this principle, of easy comprehension. It equally explains the injurious effects which follow habits of indolence and indulgence. By remaining too long in bed, or by the use of too great a quantity of bed-clothes, the accumulation of Electricity is carried beyond its proper standard, and a watery febrile perspiration is induced, by which it escapes, leaving a sense of languor and exhaustion, identical with the effects of an overcharge of Positive Electricity from the machine, under which precisely the same sort of inertness and loss of Vital Energy occurs.

There are other ways in which the natural retention of the Vital Electricity may be fostered, as by the influence of climate. This is of so signal a nature, as to show the importance of our present enquiry as it regards human health, strength, and longevity, in a very striking point of view. There is no part of the habitable globe where, from the little moisture present, and the constant absence of excessive heat, the atmosphere, is so uniformly in a non-conducting state as over the table lands of Mexico. The result is, that metals exposed to the air remain for years in a bright and unoxymdated state; a fact evident from the appearance of the copper

used to cover the roofs of the public buildings. The physical effects, too, are equally curious in another way ; for it is highly probable that the non-conducting quality of the air augments the terrestrial electricity to the extent indicated by the frequent recurrence of earthquakes in these regions. But still more marked are the physiological results ; for although he does not account for the fact, the evidence of Humboldt is conclusive as to the very advanced age to which a majority of the inhabitants live, enjoying almost to the last a capacity for exertion, and a comfortable possession of every faculty, which is not merely rare, but scarcely, if ever, to be met with in any other portion of the world.

After stating that it is by no means uncommon to see in Mexico, and half way up the Cordilleras, natives, and especially women, reach a hundred years of age ; and, that this old age is comfortable, as the Mexican and Peruvian Indians preserve their strength to the last, Humboldt mentions among other instances, that when he was at Lima, an Indian named Hilario Pari died at the village of Chignata at the age of 143. This man had remained united in marriage for a period of 90 years to an Indian who attained the age of 117, and he was himself able to walk a distance of from three to four leagues daily, up

to the age of 130. It is of importance to remember in this connexion, that the blood is propelled through the heart and arteries by their contractile power, in opposition to the weight of the atmosphere. In the locality alluded to, from the great elevation, the atmospherical weight and pressure are reduced, and two results are thus obtained ; first, the muscular force necessary to keep the heart in play is lessened ; and secondly, the Electro-Accumulation is increased by the dryness of the air.

The first particular admits of easy illustration. Taking the barometer at 30 inches, the atmospheric pressure on the entire surface of the body at the level of the sea would be equivalent to 32,325 pounds. On some of the extensive table lands of South America, having an elevation of not less than 12,000 feet, the barometer stands at $20\frac{1}{4}$, leaving a pressure equal to 21,750 pounds, which is no less than a difference of 1,575 pounds between the pressure sustained in the former and latter instances ; and which, doubtless, presents a fact highly favourable to the continuance of animal life, the more easy action of the heart keeping up the supply of blood for the nutriment of the body against the wasting agency of absorption, and the transformation of the tissues in respiration.

We shall eventually find, that Electricity, though the secondary, is yet the more active principle of contraction in the muscular fibre; and in reflecting on the valuable contingencies involved in this chain of facts, we have great encouragement to hope that, with our advance in the study, and the practical application of Physiological Electricity, new and commanding means will present themselves, not only to alleviate the sufferings of disease, but to give a higher tone to the enjoyments of health, and a greater capacity for the retention of life itself.

It were perhaps difficult to divine any test more searching and satisfactory as to the reality of our advance in a new branch of science, than to ascertain how far our steps have been planted on the firm ground of former experience in some strictly collateral path. Thus, as to the doctrines of phrenology, true in the main outlines, but weak in the details—every ignoramus may point out incongruities here and there, or refer to the instance of some extraordinary compound of villany where the whole formation of the brain was too low to show developement of any sort, but who still might have been surpassingly wicked in some horrible instance, under the force of vicious habit producing a preternatural activity of certain propensities. All this would

prove no negative ; but on the other hand, if we find that the master spirits of former times, if our Shakespeare and Hogarth describe and paint certain characters as examples of vice and folly at once from the great book of Nature with peculiar formations of the head, which these close observers knew to tally with vicious rancour, or imbecility of mind—the “forehead villanously low,” or the little conical knowledge box of the booby profligate, in the *Marriage à la Mode*—we feel at once that, as the one described and the other drew from Nature, and as phrenology arrives at the same results, it must have its origin in Nature too.

Let us, then, apply this rule to that branch of the Electro-Physiology of Man which we have now before us. If the non-conducting quality of the skin is so essential to the preservation of health, it will surely appear that a number of ancient habits have a practical and instinctive accordance with the fact, although the rationale of their use was utterly unknown. It is even so ; and what is somewhat amusing, we may take our examples from the annals of surgical treatment, though as yet, not one professional man in twenty, has the most distant idea of the really electrical principles on which his every day practice is founded.

When a breach of the skin occurs of a minute character, say a scratch, a fluid immediately exudes, termed coagulable lymph; now this fluid, if separated from the body, is capable of being rapidly coagulated by positive Electricity, and in the instance of the scratch, the case is still the same; the positive Electricity of the blood beneath coagulates the lymph,—it becomes dry, and the non-conducting character of the skin is restored: but this process, simple as it seems, is always in accordance with the Electricity of the individual:—with the feeble, it is tardy; with the strong, it is ready and lasting; with the gross and overcharged, it is partial, and attended with a degree of electrical accumulation which constitutes inflammation, and leads to supuration,—in common language, to a fester.

But, say that the injury is more important; a sabre-cut for instance, here the unassisted powers of nature are insufficient for a similar result. If left to itself, the cutaneous Electricity accumulates, and is in part thrown off by evaporation, while the oxygen of the atmosphere is absorbed, and inflammation, with pain, and all its injurious consequences, will follow, if not prevented; and how can it be prevented? simply, by suspending the electrical intercourse occurring between the exposed surface and the air. The surgeon brings

the lacerated parts as much into contact as he can; and restores the non-conducting character of the surface by putting on a plaster of a waxy resinous and oily nature; or sometimes a dressing of dry lint is employed, which is also a non-conductor. The consequence is, that the wound heals by what is called 'the first intention,' and the surgeon succeeds by practising Medical Electricity, without his having had an idea of the sort.

But, suppose that the wound has been neglected, and is already in a state of violent inflammation; what is to be done? The surgeon orders wet dressings or a poultice,—the great evaporation in either case carries off the accumulated Electricity of the part, which the dry atmospheric air could not effect; and when this is sufficiently reduced, he has recourse to the non-conducting plaster, or lint, or both, and again succeeds by Medical Electricity.

But, suppose that the patient has unfortunately been neglected to a still greater extent, and that, from active inflammation, the wound has remained an open drain for the Vital Electricity of the system, until, the due stimulating power being expended, it assumes a languid and unhealthy character; what is to be done?—the surgeon uses caustic, or orders caustic applica-

tions ; these are all substances evincing negative Electricity in a highly condensed form, and by the electrical law, which, when the opposite Electricities are approximated without combination, augments the power of each, the caustic is no sooner brought into action on the surface of the sore, than the previously inert animal substance has its positive Electricity so far increased as to give a renewed power of vascular action to the surrounding parts : with this augmented energy the proper secretions are thrown out, granulations appear, and with due time the wound heals ; and all this is accomplished by the direct agency of a chemical form of Electrical Excitement.

Blisters, the use of leeches, scarifying, and cupping, depend no less for their salutary effects on Electrical Principles ; but as they influence the internal organs, I will only name them here, and remark, that my practice has shown me the power of Electricity, in the cure of what is considered *intractable ulceration*, in a very satisfactory manner ; and that I have reason to anticipate the best results in wounds and sores of the most inveterate nature, as the vitiated state of the constitution from which they arise is generally capable of relief from Galvanic treatment.

Another means of electrical retention, in con-

nexion with the skin, arises from the Hair, which is so placed as to exert its moderating influence on the discharge of the Electricity of such parts of the body as, under the laws of the animal economy, are subject to occasional accumulation, the action of the hair in each case, being to bestow an increased energy, but one that is not positively essential. In regard to the head, for instance, the ordinary action of the hair is twofold; it preserves the temperature of the skin, under very considerable alternations of heat and cold, by which the glands secreting the unctuous part of the insensible perspiration are enabled to perform their office with greater certainty: hence the instinct which has led to the use of wigs and other modes of sheltering the head with the bald: and the adoption of silk kerchiefs and turbans in hot climates.

There are other circumstances, and some of a curious and important character, connected with Hair; but before we proceed to consider them, it is necessary to observe that, although the non-conducting properties of the skin are so strongly marked, they are only intended to favour the retention of the vital Electricity within certain limits; and that when the accumulation passes beyond the due standard, the surplus is invariably thrown off; unless, indeed, some unusual obsta-

cles are opposed, which, when they do occur, lead to great irregularity of the animal functions from a repletion of Electricity. There is, again, a secondary law of accumulation, when, although the entire quantity of Electricity in the body is not too great, or is even below the proper standard, yet, for the purposes of local excitement, and to bestow increased energy on the organic functions, or on the mental attributes, a partial accumulation occurs, as the occasion may require. Thus in the animal of prey, or in the human combatant aroused to sudden conflict, we observe an apparent increase of size, as the muscular system prepares for the coming struggle; the eyes glare with a fiery excitement, the respiration deepens, and the limbs swell with increased power. We shall find hereafter, that the reserve of Electricity within the body has been thrown to the surface; a fact equally certain in both instances, but more evidently shown in the beast of prey, whose mane stands erect, from the repulsion occasioned by the electrical atmosphere, arising from the overcharged surface beneath. This rising of the hair from excitement is a fact generally known, and most individuals have felt it more or less. It is alluded to in Holy Writ—"Then a spirit passed before my face; the hair of my flesh stood up."—Job iv. 15. Our

best authors too make frequent allusions to it, Shakespeare in several instances :

“I could a tale unfold, whose lightest word
Would harrow up thy soul ; freeze thy young blood ;
Make thy two eyes, like stars, start from their spheres ;
Thy knotted and combined locks to part ;
And each particular hair to stand on end,
Like quills upon the fretful porcupine.”

HAMLET, Act i. Scene v.

“The time has been, my senses would have cool’d
To hear a night-shriek ; and my fell of hair,
Would at a dismal treatise rouse, and stir
As life were in’t.”

MACBETH, Act v. Scene iv.

The same phenomenon, as it occurs in a subdued and gentle form under our every-day experience, has been little noticed and still less understood. I allude to different states of the hair in varieties of the human race ; and again, in persons of different constitutions ; and also, to different states of the hair in the same person under different circumstances.

The latter part of the sentence is the one more immediately connected with the branch of the subject before us. Under common circumstances there is a freedom and elasticity about the hair of a healthy individual, which not only gives a lightness of appearance, but, from its openness, allows an easy passage to the evaporations of the head. At this time, the person is fresh and full of vigour ; the vital Electricity being so balanced

as to be nearly absorbed as accumulated by the respiratory, digestive, and circulating functions; the surplus being merely sufficient to keep up the vascular action which effects the transpiration of the skin, and passing off by the insensible evaporations occurring principally from the feet, the hands, and head; with those of secreting surfaces, as the mouth and nostrils.

But let the same individual become exhausted by fasting, fatigue, or any other cause of temporary debility, and the appearance of the Hair is decidedly changed; it has lost its elasticity, and lies depending on the scalp; the eyes are sunk and dull; the skin shrunken, and sometimes cold; in other cases dry and hot, or moist with a faint perspiration. The previous vigour has given place to lassitude—the Electricity of the system has been reduced below the healthy standard, and the nervous energy is in proportion lost. The former strength, however, may be recovered by rest, food, and the lapse of a little time, during which the necessary Electricity is again accumulated.

But if, instead of mere debility, the individual suffers from disease, say fever, the appearance of the Hair is still more signally changed—it becomes disordered, in some parts clinging, in others rising, and in some cases a sort of curly

roughness occurs. In this instance, again, one of the most ancient resources of medicine is in strict accordance with the principles of the new science before us: the hair is shaved off, cooling lotions are applied, and so the brain is relieved from its distressing overcharge of Electricity, which in this example is often only sensible in the form of heat; heat being frequently the result of a peculiar Electro-Equipoise in the system to the exclusion of the other electrical attributes, precisely as in that form of galvanic arrangement termed the Calorimotor, which, while it can fuse and burn metallic bodies, can convey no shock, nor even decompose water.

The classical reader may be here reminded of the affectionate care with which Cleopatra cut off the hair of the expiring Antony, in accordance with the ancient opinion, that it gave relief to those who were dying from violent means. From the ignorance of the connexion of Electricity with the Vital Functions, which has so strangely continued to exist, this custom has been alluded to as a mere superstitious practice; and yet how satisfactorily it illustrates the subject before us—the modern habit of bathing the temples under similar circumstances is but another means of gaining the same result.

CHAPTER III.

ELECTRICAL NATURE, AND PHYSIOLOGICAL INFLUENCE OF HEAT.—OF THE ELECTRO-EFFECTS OF PERSPIRATION.—LAWS, AND MOTIVE FORCE OF THE CIRCULATION.—THE CAPILLARY SYSTEM: UNSATISFACTORY NATURE OF THE ACCEPTED VIEWS ON THIS SUBJECT: HOW FAR INDEPENDENT OF THE HEART: IMPORTANCE OF A MORE CORRECT KNOWLEDGE:—ELECTRO-NERVOUS AGENCY: OF ITS DISTRIBUTION, AND OF THE EFFECTS OF CONCUSSION.—VITALIZING INFLUENCE OF ELECTRICITY.

I HAVE alluded to the fact, that, under certain circumstances, Electricity assumes the form of heat; and as this transformation is of great importance in a physiological sense, it may be proper to add, that no more satisfactory explanation of the phenomenon has been given than that it results from a union of the two Electro-Forces. It has been ascribed to an intensity of vibration; and again, Dr. Prout says, “Different opinions have been held, some supposing that both the electric and the magnetic energies, when in a state of equilibrium, constitute heat.”—*Bridgewater Treatise*, p. 49. Now, as we do not build upon theories in these pages, we

must return to the simple fact, as shown by the Calorimotor, of the change of Electricity into the form of heat, and mention with it another circumstance quite as certain, but not better understood, which is, that heat has the power of absorbing and dissipating the other forms of Electricity. The influence of these Electrical Laws is of great moment in the Economy of Life. For instance, by the accelerated respiration, and also by the vascular turgescence, the friction and pressure attendant on muscular action during violent exertions, Electricity is rapidly accumulated and changed in character, until the animal heat is raised beyond the natural standard, and fever would ensue had not a means of relief been provided sufficient for all ordinary occasions. This constitutional safety-valve against dangers so easily induced, is supplied by the simple function of Perspiration, in which a watery fluid exuding through the pores, and saturating the tissue of the skin, annihilates for the time its non-conducting character, and establishes a general communication between the circulating contents of the capillaries and the atmosphere, and thus the overcharge of Electricity is rapidly thrown off by evaporation.

In the function of Perspiration, it will be observed that the external skin becomes the

passive subject of a law of the circulation, by which, under certain electrical circumstances, a considerable portion of watery fluid is subtracted from the blood, and lost by evaporation. We are thus led to the consideration of the Vascular System as influenced by Electricity; and here the physical forces under which the circulation of the blood is effected, must be previously stated; and of these it is presumed that the following outline will convey a sufficient idea.

First, we have the *contractile powers* of the heart and of the arteries forcing forward their contents by successive pulsations against the counteracting influence of *atmospheric pressure*: and again, by the same pressure, we have the exhausted blood returned to the heart through the passive system of vessels termed veins and lymphatics. Of these antagonist forces, it will be observed that the first must be superior to the second, and yet the second exerts a pressure equal on the average to fifteen pounds on the square inch. It is also to be noticed, that, as the blood flows from the heart, it is propelled through tubes growing smaller as they extend, and that, on the contrary, it is returned through tubes which, from fine extremities, gradually enlarge. It follows, that the connecting links of the vascular system must consist of minute

vessels, with the exception of cells or of other receptacles with which the extremities of both arteries and veins may naturally communicate. These minute tubes are termed the capillaries, and form tissues of considerable extent and of vast importance in the animal economy. Thus, the circulation of the Brain is almost entirely so constituted, the branches of the carotid arteries only entering its investing membrane, the pia mater, by an infinite number of minute ramifications, forming a web of network, while the veins are equally small until they terminate in receptacles termed sinuses:—a Second most important tissue of capillary vessels is presented by the Lungs, in which they constitute the entire substance, surrounding the innumerable cells and tubes for the passage of atmospheric air:—a Third occurs in the Liver, the substance of which is almost entirely constituted by convolutions of capillary vessels:—a Fourth is found in the Kidneys:—a Fifth in the Mesentery:—a Sixth in the Cellular Membrane and Cutis Vera, which everywhere envelope the surface of the body under the epidermis.

The distribution of tissues, constituted by capillary vessels, has been so far alluded to, as occurring in different organs, to convey a more distinct idea of their innumerable amount and

relative importance:—but we have to go still farther, and to state, that all the secreting surfaces of the body are so constituted, with certain variations in the proportionate number of arteries, nerves, veins, “true capillaries,” and lymphatics. In the tongue, in the membrane which lines the mouth, the throat, the stomach, and the intestines—and that between the fibres which form the muscles, there are everywhere interwoven an infinite number of such minute vessels.

These vascular tissues, from their hair-like minuteness, have been termed the “capillary system,” and much attention has been directed to them from the fact that they constitute the most important organs; but unfortunately little has been learnt, except such mechanical arrangements as the knife and the microscope of the anatomist could reveal. The result of such enquiries has, indeed, been only of an inconclusive character; for the evidence has shown that the fluids traversing these minute tubes were moving through the net-like loops and circles which their arrangement presents in a manner which the ordinary projectile forces of the general circulation were not adequate to accomplish, but it amounts to nothing more; for we shall find that the theory of their circulation, as given by Dr. Marshall Hall, is unsatisfactory.

The labours of that distinguished physiologist on this subject, have, however, been of great importance, as he has shown that between the extreme branches of the arteries and the veins a third order of tubes is to be found, which he terms the "true capillaries," the distinction being that these vessels preserve the same diameter throughout their course : nothing can be more distinct and able than his own description of their appearance. "The minute vessels may be considered as arteries, as long as they continue to divide and subdivide into smaller and smaller branches. The minute veins are those vessels which gradually enlarge from the successive addition of smaller roots ; the *true capillary vessels* are obviously distinct from each of these, they do not become smaller by subdivision, nor larger by conjunction ; but, they are characterised by continual and successive union or subdivision, or anastomosis, whilst they retain a nearly uniform diameter."

To Dr. Wilson Philip we are also indebted for very important facts ; for, he has proved, that the motion of the animal fluids in these minute vessels proceeds after the action of the heart has entirely ceased : that is, in popular language, for some time after death : and that, even after the division of the main artery, this

circulation in the capillary system is still maintained, and for a very considerable period. His words are, "Circulation goes on in the minute vessels after death; and when the aorta had been tied for twenty minutes or more; towards the end the blood moves backwards and forwards in the same vessel:—even when the mesentery was become cold, the motion went on."

These are very curious particulars, and clearly demonstrate that the Capillary Circulation, on which all the more intricate and finer functions of animal vitality depend, owes its propelling and circulating powers to some agency beyond the contractile impulse of the heart; and for this plain reason, that we find that it can be maintained for a considerable period after its connexion with that organ has been entirely cut off. But these particulars are not only curious,—they are highly important;—for without some rationale of the moving forces of the circulation, how can we hope to alleviate or remove disease with any certainty, when, in almost every instance, it is nothing more than an irregularity or derangement of the capillary circulation.

Without some precise knowledge of this nature, it is evident that the practice of medicine can be nothing more than what it has ever been,—the empirical application of drugs and other

physical agents, the influence of which was first discovered by chance, and afterwards confirmed by experiment; but is still uncertain,—and for this plain reason, that human constitutions vary, and without a knowledge of the vital laws on which such variations are founded, they cannot be met; and in this uncertainty every new case is more or less an experiment, in which the patient may be the victim.

I trust, that I shall presently be able to show that this unknown controlling influence on the Capillary System is Electricity: but in the first instance, I would quote the theory of Dr. Marshall Hall, and point out the particulars in which it appears to me to be erroneous.

“I would remark that the due diffusion of the blood in the minute and capillary vessels appears to be regulated by a principle of *tension*, subsisting between the contents of these vessels, their parietes and integuments. It is on this principle that the blood leaves the web” (in the foot of the frog) “as the powers of life decline. It is on this principle that the blood flows into other channels when its proper channel is obstructed. It is on this principle, that the blood flows in all directions to the point at which a vessel is wounded or opened, as in the experiments of Haller or Spallanzani. It is on this principle,

that there is an apparent circulation in the minute vessels after the excision of the heart, or the division of the large vessels of a limb. This movement of the blood is towards the point of division, and therefore retrograde in the arteries."

Before we investigate the principle of tension, as referred to in the above, we may pause to notice the false conclusion which the latter clause of the quotation would involve. Dr. Marshall Hall speaks of the motion of the blood in the capillaries as being towards the point of division when the heart has been cut out, or the large vessels of a limb divided—now this absolute section of the vessel defeats one of the main objects of the investigation:—we can very easily understand, that the motion of the blood in the capillary vessels may be towards the retrograde stream in the arteries with an open orifice; but what we want to find out is,—how it happens, that the capillaries continue to act when no such excision or division has been made, but when, on the contrary, the aorta has been carefully tied, as in the experiments of Dr. Wilson Philip; or, as it occurs after death, when the heart and all the large vessels have remained untouched. It is then, that the motion of the blood in this secondary system of vessels has been seen to continue for a period of twenty minutes, with a

flow at first regular, then receding, and next increasing;—then irregular, then moving partially in circles, and lastly, moving backwards and forwards in the same vessel.

Now we are told by Dr. Marshall Hall, that all this is the result of tension existing between the moving fluid and the parietes and integuments of the vessels in which it is contained. We have then first of all to ascertain, what is meant by the term *tension*, as used for the principle in question; it is not the tension of Electricity, nor is atmospheric pressure alluded to, but it is *tension*, in the simple meaning of the word, which is nothing more than the pressure arising from the mechanical distention which occurs when an elastic tube is filled with water or any other fluid.—This sort of tension would indeed, with the aid of atmospheric pressure on the known laws of hydraulics, be sufficient to produce that kind of flow towards an opening, and the weak irregular motion noticed “*as the powers of life decline*,” but it is altogether inadequate to support the circulating movements which are to be observed after death, and when the escape of the blood has been prevented by tying the aorta. And we have moreover a decisive proof,—indeed a perfect demonstration, that this mechanical principle of tension has little or

nothing to do with the matter;—for when the brain or spinal marrow of an animal has been *crushed*, this flow, this motion, or circulation, ceases at once, and altogether. Under these circumstances, it is impossible not to admit the conclusion drawn by Dr. Wilson Philip, that the motion in the vessels in question is the result of, and under the control of the nervous influence: nervous influence being, in his view, identified with Electricity. For instance,—if it arose from the mechanical law of tension, the destruction of the brain could not for a moment impede it: when on the contrary, while the nervous system is left entire, it is seen to go on in the mesentery for more than twenty minutes after death, and even while the part itself is growing cold.

This influence of the nerves is, indeed, evident from the structure, for nervous filaments everywhere accompany the minute arteries. Dr. Marshall Hall says, “It is a remarkable fact, observed in the web of the frog, that the minute nerves pursue a course close to the minute arteries.” The nervous influence is again shown by the fact, that when the nervous connexions are withdrawn, secretion and the transformation of the tissues on which the accumulation of animal heat depends immediately cease; although, as in the experiments of Sir Benjamin Brodie on

decapitated animals, the action of the heart and the circulation of the large vessels may be for a while maintained by artificial respiration.

The essential influence of the nerves being then admitted, it becomes a question how this influence is at once destroyed and dissipated by crushing the brain, or the spinal marrow?—We answer, by that law of Electricity, by which one violent discharge in its passage absorbs all the separate minor Electro-Currents established in the same body, if constituted by parts, having different capacities for retention, such as are presented by the animal tissues and fluids. We have, indeed, an example of a similar character, in the curious fact, that a violent blow will immediately deprive a magnet of its power. And again, in cases of sudden death, from passion, blows on the stomach, or Electricity, the blood remains fluid;—and so completely is the latent vitality withdrawn, that the muscles do not contract, but are at once rendered insensible to the galvanic influence.

It should here be observed, that the coagulation of the blood is the result of its *electrical tension*; and that fact seems the more directly to suggest the question, that if Electricity is so far the agent of motion in the circulation, of vital character in the blood, and of contractile

power in the muscular fibre—how is it, that its artificial use, as by galvanism, will not supply the deficiency arising from the sudden subtraction, caused by the crushing blow, or by the flash of lightning?—We answer, that the retention of life does not depend upon the absolute quantity of Electricity existing in the body, which may be rendered greater than before, but on the due distribution of the two electricities in a certain order, and in proportion to the different fluids and organic structures; as, for instance, the positive electrical character of the blood, and the *negative* of the bile and its excretory organs. Now, the violent concussion and intense vibration extended to the entire system, by the injuries alluded to, are precisely the means by which the different electrical attributes of the organic structure in question would be most easily subverted.

We see, indeed, the same result, to a great extent, proceeding from more common causes—for when death follows a long continued wasting of the animal powers, it frequently comes on in the gentle form of stupor, or of sleep; but when it is the result of causes which have left the general muscular strength unimpaired, the final efforts are often of a convulsive character,—each death-struggle being, as it were, an explosion of

the retained electro-energy, and each becoming weaker as that energy exhales.

These differences are evidently shown on the field of battle; the soldier who has fallen from the sudden shock of a musket ball, which operates on the entire system, lies with his limbs relaxed and his countenance serene; while he who has died from sabre cuts, or stabs from the bayonet, presents a fearful picture of convulsive action in the distortion of the features and the contraction of the limbs.

Again, it may be asked,—how is it that the Vital Electricity of the body is not as suddenly subtracted by sword cuts and by stabs, seeing that these injuries are inflicted by good conductors?—We answer,—that the whole arrangement of the Vital Electricity is such, as to guard against any sudden and accidental loss of its power from the contact of conducting bodies; and that the fatal result in cases of *shock* is not the loss of Electricity, but the destruction of its due arrangements and character, by the passage of absorbing currents, or by the confusion incidental to intense vibration. For instance, the body of an animal which has died by strangulation, or any other means by which the nervous system is mechanically uninjured, and its due state of electro-tension retained, is capable of

being intensely excited by Galvanism ; and if such a dead body is cut into separate pieces, each limb will still admit of galvanic excitement ; and this division of a body, exhibiting given electrical arrangements, such arrangements still remaining in the separate parts, is curiously in unison with the fact, that a bar magnet may be cut into twenty pieces, or more, and that each will be still a magnet ; when the *concussion* of a single blow with a hammer on the bar when whole, would have dissipated its magnetism at once.

The fatal influence of Concussion on remote parts, as, for instance, on the brain and respiratory nerves, by a blow on the stomach, is beautifully illustrated by the following experiment of Dr. Marshall Hall. Having separated the hind quarters of a frog from the trunk, both the limbs were found to contract as usual on the application of the Galvanic influence :—one of the limbs was then crushed by a blow with a hammer, and the result was, that the other and apparently uninjured limb, had from that moment lost all power of contraction. In this instance, the centre of the electro-nervous agency was that lower part of the spinal marrow, termed the “*cauda equina* ;” before the blow, this energy existed in a state of tension in the nerves of both

limbs, and in their connecting centre ; on the use of voltaic electricity, an overflow of this energy occurred, and with its discharge the muscles contracted, but still leaving the proper electro-tension—by the crushing blow, all the due separate electricity of these nerves is at once discharged, and the precise condition of its former distribution cannot be restored by artificial means. It is probable, indeed, that the organic arrangements for the insulation of electro-force in the nervous tissues are mechanically injured by the explosive vibration following Concussion ; and the extreme delicacy of the organic arrangement may be imagined, when it is stated that Faraday has charged the separate sides of a strip of gold leaf with the opposite electricities.

It will be collected from what has been previously said, that if Electricity is employed under Vitality, to give activity to the circulation and other functions of the Capillary System, that as long as the characteristic electricity of the part remains in a latent form, although the nervous connexion has been cut through, yet, that the functions in question may be artificially excited in a living body, and supported by supplying the severed nerve of the part with a Galvanic Current instead of the electro-nervous energy

which it previously received from the brain and spinal cord.

This conclusive proof of the commanding and vitalizing influence of Electricity now stands on secure and unquestionable grounds; the facts which constitute its evidence having been publicly tested in most of the Medical Schools of Europe. I allude to the discoveries of Dr. Wilson Philip as to the eighth pair of nerves. These nerves are distributed to the lungs, the diaphragm, and the stomach, and by their agency the great functions of Respiration and Digestion are maintained. When the connexion of these nerves with the brain has been cut off by the excision of a part, the breathing of the animal becomes very much embarrassed; distressing collections of phlegm arise, and a slow sort of suffocation destroys the animal after a short interval of time; and whatever food has been given to it immediately previous to the operation, will be found in the stomach perfectly unchanged, while the capillary structure of the lungs will, on examination, present a mass of diseased vascular tissue, scarcely a trace of the healthy appearance being left. But if, instead of leaving matters to their natural issue, as in the former instance, after this extraction of a part of the nerve, its lower end be connected

with the positive pole of a Galvanic Battery, and the other pole brought into contact with the skin over the stomach, so as to institute a current of Voltaic Electricity through the intervening space occupied by the lungs, diaphragm, and stomach, the result is, that the collection of phlegm is prevented, and the breathing continues for a considerable period but little impeded ; and if the animal, having been fed as in the previous instance, just before the operation, be now killed and the stomach opened, the food will be found to have undergone the usual change ; the gastric juice of the stomach having been duly secreted, under the influence of the Galvanic Current.

Now, the due secretions of the lungs and stomach being thus maintained by electrical agency, it follows, that the capillary circulation and glandular apparatus, by which the blood is furnished, and the fluids in question are separated from it, must also be equally supported ; and this is the more evident from the little change to be observed in the appearance of the lungs in the latter instance. These facts speak for themselves, and require no collateral evidence : but still it may be as well to state, that without any operation, the galvanic influence has been most successfully used in a similar way, as a

medical agent, in many diseases implicating the lungs and stomach, and that too, several years ago, and with comparatively imperfect apparatus, by Dr. Wilson Philip. Even in a case of apoplexy he states that, "after the rattling breathing had come on, and the patient seemed about to be suffocated, he was at least a dozen times made to breathe with ease, the accumulation of phlegm gradually disappearing on the application of galvanism, by which his life was evidently prolonged."

CHAPTER IV.

ELECTRO-PHENOMENA CONNECTED WITH THE ACTION OF THE HEART.—ON THE INFLUENCE OF ELECTRICITY ON THE BLOOD AS A FLUID: ON ITS CHANGES IN RESPIRATION: ITS ANTISEPTIC QUALITY, COAGULATION, AND ITS NUTRITIOUS PROPERTIES.—LAWS OF ELECTRICAL ATTRACTION, AND REPULSION, AS AFFECTING THE VASCULAR ACTION; AND THE CONSTITUTION OF THE BLOOD.—INFLUENCE OF THE ELECTRO-FORCES ON THE SMALL ARTERIES AND ON THE CAPILLARY SYSTEM: EQUALIZING EFFECTS ON THE PULSE, WITH PRACTICAL ILLUSTRATIONS, IN INSTANCES OF CHRONIC DISEASE.

IT is a universally admitted fact, that the Blood is itself the stimulus which excites the muscular action of the Heart,—the contraction occurring when the auricles and ventricles, or, in other words, the hollow pouches of the heart are filled; and as the muscles contract under electrical excitement, we see at once that nothing can be more simple and beautiful than the *modus operandi* of the action in question. It is a known law, that all bodies by sudden compression give out a portion of their latent Electricity in a more or less sensible form. With atmospheric air this is so evident, that it is only necessary to

take a tube closed at one end, where a little tinder has been put, previously treated with nitre, and having a piston which fits the tube, to drive it down with a smart blow of a hammer, and the tinder will be at once fired by the electricity extricated from the compression of the air within the tube. The phenomenon in the instance of the heart is in principle the same. The muscular coats of that organ are, previously to the contraction, possessed of latent electricity of the positive character, but not to the extent which can produce contraction; but no sooner does the due charge of newly vitalized blood, hot from the lungs, enter the heart, than a portion of its superior positive electricity is transmitted to the whole muscular structure of that organ, which, with this supercharge, immediately contracts, and the crimson tide of life, vivified by the etherial fire of the universe, is thrown with a sudden gush upon the arterial system, and constitutes the marked vibration which we call pulsation. It is evident that this powerful demonstration of electrical action must require the intervention of a most efficient non-conducting medium, to restrain its expenditure in the form of lateral discharge, and this is precisely the case; for in the fat with which the heart is, in all instances, more or less provided, we have exactly the medium required;

and it is an interesting fact, that as age advances, and the arteries are inclined to become rigid, and the muscular coats of the heart thin, the quantity of fat around it is in proportion augmented, as a means of greater concentration.

It is hardly necessary to remark, that the right side of the heart, which supplies the circulation of the lungs, acts at the same moment, and under the same impulse, the muscular fibres of both sides crossing each other, and being most intimately connected, as if it were for this immediate purpose.

Another point of moment is, that the internal surfaces of the heart are admirably adapted to imbibe the super electricity of the blood, as they have deep grooves on the sides and transverse bars of muscular structure between them, so as to present an extra extent of space for the stimulating action of the received blood.

The few and very slender nerves distributed to the heart, are connected with the *sympathetic*, and *par vagum*; and, small as they are, are quite sufficient to withdraw enough electricity from the heart during mental emotion to enable it to sympathize duly with the respiratory functions; indeed, if the nerves were larger, the heart would be subject to fatal interruptions of its action, and would be a voluntary, instead of an involuntary organ.

The connection of the arterial action with the secondary circulation of the capillaries is evident from the fact, that it is by this action that their supply of blood is maintained : and it now becomes a point of great interest to ascertain, what is the immediate action of electricity on the blood as a fluid.—First, the Electro-Tension preserves the blood by its antiseptic influence ; this is shown by the fact, that animal membranes may be preserved from putridity by being kept in contact with the positive element of a galvanic arrangement, as I have tested by experiment : and it may be observed that charcoal acts on the same principle. This antiseptic quality of the blood is of great importance, and the want of it, whether arising from the respiration of impure air, the expenditure of electricity, by muscular exertion too long continued, or any other cause of debility, is a leading and an aggravating feature of disease ; for, as it is remarked, in the Lectures of the immortal Hunter—“ In many diseases not inflammatory, the solids have a tendency to fall into those changes natural to animal matter deprived of its *preserving principle*, the blood has no tendency to coagulate, nor the solids any power of raising inflammation, both having taken on the same tendency. In such diseases, the principle and powers are diminished, so that

life is hardly able to preserve the matter from falling into the natural changes."

Secondly, that the power of coagulation in the blood depends on its relative electricity; and as we find that out of the body the albumen of the blood can be separated by voltaic electricity, there can be little doubt, but that by this agent, fresh matter is deposited from the blood for building up the internal structures, precisely as we can forward the formation of new skin, and renew the healthy secretions in old and indolent ulcers, which had resisted all other medical means, by galvanic treatment.

Thirdly, the laws of Electrical Attraction and Repulsion have an essential influence on the Vascular Action, and on the constitution of the Blood. Thus we find, that the surplus electricity of the blood induces the following results:—The blood and the artery or vein in which it is contained, being both in a positive state of Electricity, repel each other, precisely as is seen in the instance of mercury contained in a glass tube, when the upper surface is highly convex notwithstanding the weight of the metal.

This mutual repulsive force between the sides of the blood vessels and their contents is of great use in removing the friction which must otherwise have occurred; but there is another sense,

in which this law of electrical repulsion is of still greater importance. It regulates the consistency of the blood:—and here again, we may remark an instance of that evident design that is every where to be observed in the works of the Creation; for the compound character of the blood as a fluid sustaining an infinitude of free globules, is precisely such as gives the most commanding scope to the repulsive law of electricity. All round conducting bodies have a greater power of retaining electricity than those of any other form; and as the chemical components of the globules give them a greater power of absorbing electricity, than the more simple serous fluid in which they are suspended, so they obtain a higher degree of repulsive force, and are in consequence prevented from coming into contact, and an increased capacity for motion and greater fluidity is the result.

The careful analysis of Dr. Rees, and more recently that of Liebig, have given a peculiar form of fat, as one of the constituents of the blood; and this is probably so arranged in the living fluid, as to aid the retentive faculty of the corpuscles or globules, while the other products are all such as serve to render it a good conductor of electricity, the chlorides and other saline bodies, with the carbon being all of this

character. It is farther to be observed, that the superior quantity of oxygen in the arterial blood renders it the more prone to give out its electricity to the nerves and secreting organs ; while the extra carbon, and comparative want of oxygen in the venous blood, increase its capacity for the absorption of electricity and its power of retention, until it is brought in contact with the oxygen of the atmosphere in the lungs, when part of its electricity enters into new arrangements, and the residue, with some addition from the respired air, animates the arterial blood, and becomes the source of animal heat.

I would here remark, that the superior conducting quality of the blood must induce a current of electricity in the course of every artery of the body, the force being expended in the changes of assimilation ; and the great comparative force of the circulation in the capillary vessels is in unison with the fact.

Again, as the nerves are distributed in conjunction with the arteries, the Vital Electricity of the arterial blood may be immediately transmitted to them, and carried to the spinal cord, or to the brain, or furnished by the branches of the nervous ganglia to sympathizing parts. The extra electricity is probably absorbed by the venous blood and by the lymphatics, and if

needful, again given out on accumulation, in the secreting organs ; so that a complete system of electrical absorption, circulation, and expenditure on accumulation, and of general equilibrium under ordinary circumstances is the result.

It follows from these mutual laws of the Vascular System and of Electricity that the decomposition of so much food as the stomach can easily digest, must, by raising the quantity of Vital Electricity to a surplus, give increased strength and activity :—but if the quantity of food is too great to be readily digested, additional electricity is withdrawn from the system at large for its decomposition, so as to produce inertness and debility. A loaded state of the digestive organs, at the same time prevents a due action of the diaphragm, and the impeded respiration induced, is a secondary means of injury, by preventing the due absorption of electricity from the air, and the arterialization of the blood.

Exercise, within certain limits, is another means of augmenting the Vital Electricity, both by the general excitement, and the accelerated respiration it induces ;—but, if the exercise be continued too long, the accumulated electricity takes on the form of heat, with a consequent loss of energy, and an oppression of the brain ; or under more favourable circumstances, the ca-

pillary vessels relieve themselves from the effects of overcharge, by an exudation of part of the watery portion of the blood, which by producing perspiration, as we have previously explained, renders the epidermis a conductor, and as it evaporates carries away the extra electricity, but as it happens, that in all forced discharges of electricity from the human body, more than the proper quantity escapes; a lesser, or greater degree of debility invariably occurs.

It will be remembered that the capillary vessels have been mentioned, as a *secondary* portion of the vascular system, while they have been referred to, as constituting the most important organs and accomplishing the most delicate and essential functions. They are secondary only, in regard to the moving forces of the great circulation. The contractile force of the arterial system loses its impulse on the net-like inosculation which these fine tubes present; while the counter force of atmospheric pressure gives no determined current when operating on a series of vessels which every where open into each other with intersecting branches. This sort of circulation in the general sense is precisely such as will occur if we put a sponge into a water tight bag, inject fluid into it on the one side, and add a waste pipe for its escape on the

other.—The sponge will remain passive, and the fluid which occupies it will move and escape only, as it is injected on the one side, and passes off on the other. So is it with the Capillary Circulation, as regards both the arteries and the veins ; the first inject blood into it, and the second are the passive mediums of its exit. But the Capillary System is subject to a moving impulse beyond the sponge ; its vessels are in different degrees, according to their character, subject to dilatation and contraction from an accumulation or discharge of electricity, either locally evolved by assimilation, by pressure, or friction,—or conveyed to and thrown upon them by the nerves ; and by this means the fluids they contain are put into motion in accordance with the electrical currents excited—thus as they become exhausted, and half emptied, as in the experiments of Dr. Wilson Philip, the passage of the blood backwards and forwards in the same tube may be accounted for by the counter attraction subsisting between the opposite electrical poles, the empty part of the tube being negative, and vice versa when the positive blood flows in upon it.

The investigations of Mr. Liston, on the growth of the blood vessels which arise during the healing of a wound, as published in the Transactions

of the London Medical and Surgical Society, are of value in this connection, as they show that the arteries do not terminate in open orifices, or exhalents, as had been the received opinion, but that their finer ramifications unite in the form of loops, the returning branches forming the red veins mentioned by Mr. John Bell. From these particulars it is evident that the moisture which lubricates the inner surfaces and membranes of the body, is not poured out by open orifices, except in the instance of especial excretions, but that it exudes from the coats of the vessels, exactly as the oxygen of the air is imbibed through the surfaces of the vascular system of the lungs.

A more beautiful arrangement in reference to the laws and action of Electricity could not have been imagined. The result is, that in the fine and anastomosing vessels of the Capillary System, the accumulation of Electricity by expanding the fluid increases its pressure, and renders it thinner and more capable of filtering through their sides, while on the minute arteries, it bestows an increase of contractile power.

It will be observed that the serous fluids are here alluded to ; peculiar secretions being thrown out by the excretory ducts of their proper glands. It is from this influence of Electricity, on the

arteries, and the Capillary System, that its extraordinary power on the pulse is derived; that influence being the faculty of restoring the due equilibrium of the entire circulation in a great variety of instances.

Thus, I have almost invariably found, that if the pulse of a patient had assumed the habit of being unduly quick, from an irritable state of the system, it became slower and fuller on the use of galvanism;—and again, that when the pulse has been languid from debility, it has been rendered, by the same means, both quicker and firmer.

In several forms of *Fever*, the result is still the same; and I am glad to have my own evidence on this point corroborated by that of Mr. Charles Woodward, the well known member of the Royal Society, who informs me, that in a case of fever from acute rheumatism, he has known the pulse reduced from a hundred and twenty, to eighty, while a profuse perspiration was induced at the same time by the use of a commanding form of Electricity.

In the cure of those obstinate cases of intermittent fever mentioned by Dr. Hodgkin, in the Appendix to the Translation of the work by Dr. Edwards, on the Influence of the Physical Agents,—as cured by Mr. Smith of Fordham,

with Electricity, the same result occurred ; and that gentleman informs me, that he has seen the most signal instances of this equalizing influence of Electricity on the circulation, on other occasions.

This principle is one of the first importance, in a practical sense, and by its careful application I have been enabled to restore the constitutional powers of patients suffering under chronic forms of disease, so far, that the symptoms have disappeared, as it were, spontaneously, as the renovated strength became confirmed into general health.

In no instances has this constitutional treatment been more effective than in affections of the brain :—thus a gentleman suffering under some of the worst forms of indigestion of several years continuance, and whose disease had been justly ascribed by Dr. Dickson to a weakness of the nervous system—felt a sensation over the left hemisphere of the cerebrum (from an improved state of the local circulation, inducing strength) during my first application of Galvanism, although the current was confined to the trunk and limbs ; so that the benefit conferred on the brain arose from the sympathy of the capillary circulation of that organ with that of the body at large.

This improved state of the brain was altogether lasting ; although, from the very serious nature of the case, it required three months of the most careful galvanic treatment, combined with other remedies, to restore the patient to perfect health ; the condition of the blood having been in that period very materially improved, and a firmer growth of muscle induced.

Another instance may still farther explain the salutary and commanding influence of Voltaic Electricity on the circulation of the head.—A gentleman of seventy-four years of age, whose father had died from paralysis, and whose mother had been the victim of apoplexy, and whose hereditary tendency towards a loaded state of the circulation of the brain was evidently marked, although his intellectual faculties were in full vigour, and his stamina in the general sense was very good—consulted me with a view of having this state of the head relieved. The symptoms were of a threatening aspect, a frequent loss of recollection in point of dates and names ; a sense of heaviness about the forehead ; —feet generally cold on going to bed,—and some inertness of the limbs in walking, with sudden chills over the spine of very frequent occurrence.

In this instance, my greatest efforts were

made to withdraw the blood from the head by increasing the general arterial action in the trunk and extremities, and, as a natural consequence, inducing a rather more energetic action of the digestive organs. Proceeding on this plan, the symptoms rapidly gave way. The chills in the back became very slight, and seldom occurred;—the sense of weight over the forehead passed away;—the recollection was better;—the feet comfortably warm; and the motion of the limbs easy and energetic.

The effects on the Capillary System in this instance were of a very marked character, as during the application of galvanism the hands often became swollen and dark with the extra quantity of blood thrown into them. The patient was also relieved from a slight undue degree of corpulency, which the former weaker state of the circulation had induced.

It may be proper to add, that the benefits in this instance have been permanent, and that the general health is altogether good.

These commanding results in the vascular system were doubtless obtained by the influence of Electricity both on the vessels and the fluids they contain; but there are other objects in which the action of Galvanism, in giving an increased power of contraction to the arteries,

becomes a matter of great moment.—In cases of inflammation, particularly in the chronic form, where the arteries remain preternaturally distended, from the loss of contractile power in their coats.—In cases of congestion, or determination of blood without inflammatory symptoms, and occasioned by obstructions, or arising simply from debility, as in a great variety of cases of deranged health in the Female constitution.

CHAPTER V.

THE ELECTRO-PHENOMENA OF DROPSY : BENEFICIAL EFFECTS OF GALVANISM, WITH PRACTICAL PROOF.—OF VARIOUS FORMS OF VOLTAIC ELECTRICITY.—GREAT IMPORTANCE OF CORRECT VIEWS AS TO THE ELECTRICITY OF THE BLOOD.—OF THE ELECTRO-TENSION OF THE BRAIN AND NERVES.—SINGULAR PHENOMENA.—ELECTRICITY ESSENTIAL TO LIFE : ITS ARTIFICIAL USE A MEANS OF PREVENTING THE OCCURRENCE OF CONSUMPTION AND OTHER CHRONIC DISEASES IN YOUNG PERSONS, AND PARTICULARLY IN FEMALES.

THE influence of Electricity on the Vascular System, as explained in the former Chapter, applies with still greater force in instances of Dropsy,—there being in this disease not only a great debility of the minute vessels of the secreting surfaces affected, but at the same time a peculiar change in the lymph they exude, which has lost its power of coagulation. We have seen that this latter quality depends on the Presence of the Electro-Positive-Force. Hewson states, that if the fluid moistening the cavities be collected, it will coagulate if exposed to the air; and in making the allusion, Sir Charles Bell has a note, stating that “in Dropsy,

the fluid of the abdomen loses the property of coagulating on mere exposure; it resembles more the serum of the blood.”—*Anatomy*, vol. ii. p. 315.

Under these views, it will be seen that two advantages are obtained in Dropsy by the use of Galvanism:—first, a greater coagulating power in the lymph; and secondly, a more efficient constrictile action in the vessels. In this disease, there is a peculiarly relaxed state of the minute arteries, under which an inordinate quantity of serous fluid is thrown upon the capillary system, and there exuding, collects between the mucous membranes, which lie in contact with each other within the body, that *contact* being what is so absurdly termed in anatomical language, a *cavity*.

To obtain some idea of the advantages to be derived from Galvanism in such instances, we have only to contrast them with the very inefficient means of counteraction which the ordinary resources of medical practice present. The medicines thus employed have a tendency to increase the fluid excretions, and are therefore given with the hope of throwing off the watery portion of the blood. They are the milder forms of mercury, with squills, gentle purgatives, and stomatics, with the occasional use of digitalis,

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to lower the force of the arterial action, when the state of the pulse will warrant its exhibition.

Now, it unfortunately happens, that all these drugs have a tendency to produce debility, and cannot be long taken even by a person in health without bringing on an enfeebled state of the vascular system; so that their use in dropsy is always of the most equivocal character, and frequently most injurious.

In the lucky instances, by acting as a sudden drain, while there is sufficient latent constitutional power to take advantage of the temporary evacuation of watery fluids, they are of service, and the recovery of the patient follows:—but in the great majority of cases the appearances of relief are very transient, and generally only the result of atmospheric change in point of dryness and warmth; so that the disease marches on with slow and stealthy steps, until at last, the patient sinks, after, it may be, two or three reprieves by tapping.

There are, of course, other instances in which dropsy, having arisen from accidental causes, such as pressure, or inflammatory affections, is capable of permanent relief by the operation in question: but this is not the dropsy arising from general debility and loss of constitutional

power, of which we are treating, and in which galvanism, by giving a renovated tone to the vascular system, is, with the due combination of other means, a most commanding remedy. Even in cases in which dropsy occurs in connection with other diseases of the worst character, we may still hope for a favourable result, by restoring the healthy degree of contractile power to the arteries. Thus, in the instance of a gentleman of upwards of sixty, who suffered from paralysis of the cerebrum to the extent of indistinct articulation, with a preternatural flow of saliva, and who at the same time had his lower limbs so much loaded with fluid as to be about half as large again as their natural size—a perfect relief from the dropsical effusion was obtained in a period of twenty-eight days.

This gentleman's case, previously to his introduction to the Author, had been considered as altogether hopeless; and he had been under surgical treatment for the affection of the limbs, with the very questionable use of bandages, for many months without the least indication of benefit. In this case, the electrical applications were made very much in the form of *quantity*, with very gentle vibrations; and minute doses of a proper agent were administered, in conjunction with the galvanism, to induce a daily natural

evacuation from the bowels, which were stated to have remained in the most irregular and disordered state for many years. The absorption from the legs was rapid in the first instance; and from measurements taken by a friend of the patient's, from time to time, and which are now before me, I observe that the reduction in the circumference sometimes amounted to as much as a quarter of an inch in two days.

It is on the same principle that Galvanism proves so effective a remedy in the treatment of indolent swellings of the joints, and of other tumours arising from an enfeebled state of the constitution; but in these, as in those forms of disease previously mentioned, it must be fully understood that much—I had almost said, that everything—depends upon the character of the electricity used, and on the mode of its application.

On the whole, I have found it desirable to employ the electricity of *quantity* to a very commanding extent, and under various arrangements as to the character of the batteries, their size, and number. The continuous current has occasionally been the form used; and at other times the impulsive vibrations of streams of different intensity, as obtained from an electro-magnetic apparatus of very careful con-

struction, and capable of an extensive range of effects. I have also other apparatus of perfectly original plan, by the employment of which I have been enabled, in many instances, to carry out successfully new forms of treatment, which would otherwise have been impracticable. I have found, too, that great changes in the mode of galvanic application, as addressed to the same patient at different times, have been of signal advantage, the constitution being roused by alternations and sudden impressions of this nature to an extent which could not be obtained by any uniform exhibition of power, or mode of application.

I have introduced this digression, lest it should be supposed that I had relied on any of the common and superficial modes of exciting the nerves in cases of the above description ; and I will now proceed to the consideration of Galvanism as addressed more immediately to the Nervous System.

No mistake has been more common, and none could be imagined more mischievous, in a practical sense, than the idea that the accumulation of Electro-Force in the human frame resided in the brain and nerves, for as the most insignificant portion of electricity in the form of *intensity* is capable of awakening acute sensation although

unable to give one iota of increased chemical agency to the blood, it was often supposed, that the effects would be in proportion to the mere feeling of the moment, and thus persons have in this way been electrified for successive months without the shadow of a benefit.

We cannot too often repeat that the great repository of animal electricity is the Blood ; and there is one experiment by Fowler, of a very conclusive character in this particular. No animal is more capable of galvanic excitement than the frog ; and after having separated the lower extremities of one of these animals, from the trunk, he prepared them in the following manner :—from the one limb, he dissected away the blood vessels as far as possible ; and from the other, the nerves, when on testing them with the same galvanic power, it was found that the muscular contractions were much stronger in the leg deprived of its nerves than in the other where the nerves were retained, but the blood and its vessels were wanting. It was also found that the susceptibility to electrical excitement was retained much longer in the limb with the blood-vessels, than in the other.

Equally conclusive evidence of the importance of the blood to the cerebral action may be adduced ;—Mr. John Bell states that “ the brain,

which weighs not a fortieth part of the whole body, receives one tenth of all the blood, a proportion which must occasion surprise :” and Sir Charles Bell writes as follows : “ If the blood flows too rapidly upon the brain, the intellect is disordered, the ideas come in rapid and irregular succession. If the exit of the blood from the head be obstructed, there is an obstruction to the circulation of the blood in the extremities of the vessels of the brain ; the function of the brain is suddenly suppressed, because though its attributes seem so peculiar, it requires the perpetual circulation of the blood through it, to support its powers.”—“ If the great artery of a limb be tied, the function of the nerve is in a short time equally destroyed.”

We have here to remember, that the living blood has ever a surplus of positive electricity except when partially decomposed in the last stage of virulent fever,—and that, as we find this electro-positive state essential to the blood,—so is the blood in this state, equally essential to the functions of the brain, and the nervous system ; and that, as at least a tenth of the blood of the entire body is engrossed by the circulation of the brain, it is apparent that, that organ must also be in a constant state of positive electricity. The medulla oblongata, spinal marrow, and

nervous system are evidently under the same conditions ; and all, together with the brain, are charged with positive electricity, which, though accumulated under the common laws of electrical induction, is afterwards modified and controlled by the superior and unknown Principle of Vitality, and becomes active as Nervous Energy, the great source of power, and the exciting agent in the phenomena of Life. It is thus that the nerves of sensation and of voluntary motion are capable of arousing the arterial circulation of the organs to which they are directed, with that increase of electrical power which we call excitement ;—and that, on the other hand, that if the surfaces or organs with which they communicate are stimulated externally, the electricity so accumulated leads to the same excitement, and the local sensation is carried back to the sensorium by the nerves.

From what has been already said, it will be apparent, that a certain state of electro-positive tension is essential to the life of the blood, to the due separation of its globules, and to its motion in the capillary vessels, and that an evident induction of a portion of this electricity is necessary to support the functions of the nervous system ;—and we will go on to state, that there is great reason to conclude, that the electricity so

absorbed from the blood becomes *intense* in the nervous system, as we find that form of electricity, when artificially employed, at once, producing contraction and sensation which are the first results of nervous action, while the animal chemistry of secretion and heat is only to be supported artificially, as in the experiment of Dr. Wilson Philip, by a combination of the electricity of quantity, with that of intensity, which presents precisely the compound action of the two forms of electricity that we have considered to exist in the vascular and nervous systems.

There is, however, reason to conclude, that the difference between the electricity of the blood, and that of the nerves, is not alone the superior intensity of the latter, but that currents exist uniformly in the sanguiferous system, while the electricity of the brain, the spinal cord, the nerves and ganglia, is in the passive state one of tension, and in the active, one of vibration, on the principle of induction.

It is to be understood, that in the electrical tension of the nerves, there is, as in other cases, a certain degree of accumulation, with a progressive movement, which in their instance is directed towards the brain. This view will explain the loss of sensation below a ligature, and the increased sensibility on the affected side occurring

in hemiplegia, when the tension is augmented by the intermediate pressure in which the disease originates, impeding the gradual absorption of the Electro-Vital Energy by the brain.

In this latter fact, we have too an illustration of the source of the nervous electricity; for as the minute nervous filaments pervade the capillary system, their electricity is evidently absorbed from the minute arteries which are found to be so immediately associated with them, and doubtless for this express purpose, while the reciprocal action of the multitudinous electrical currents of the minute blood-vessels on each other would add the necessary character of *intensity*.

The character of *quantity* in the primary electricity of the arterial and venous blood is no less indicated by the circumstances of its extrication and accumulation, which evidently occur from chemical changes, such as the decomposition of atmospheric air and the evolvment of carbonic acid gas in respiration, the decomposition of food in digestion, the process of assimilation, and that of secretion, the transformation of the albuminous portion of the blood into gelatine in the growth and reparation of the animal solids. The great quantity of electricity so accumulated would undoubtedly give birth to very striking

electrical phenomena in the common sense of the word ; and the mere act of taking a lady's hand might occasionally subject us to the shock of a discharge equal to that of a torpedo ! were it not for the necessary ordination of animal heat, in which form, part of the accumulated electricity is absorbed and afterwards partially expended by perspiration and radiation. Yet, notwithstanding this provision, in some individuals the electro-tonic state of the whole system has been so habitually high, as to exhibit the most extraordinary indications of free electricity on the surface. Ezekiel di Castro, a physician of Verona, relates, that Cassandra Burgo, a lady of that city, was so highly electrical, that whenever she touched her body with a linen cloth, it emitted sparks in great abundance, and with such a crackling sound as to be perceived by persons near : ” and the same phenomenon occurred in the person of Antonio Ciamfi, a bookseller of Pisa.

These circumstances are curious, simply as they are unusual ; but of no importance, as the external electricity of the human body is a secondary result, and not connected with the arrangement of the vascular currents, and other electrical agencies of the vital functions. It is, in fact, nothing more than an indication of the surplus electricity of the entire body ;—and as

the blood is positive, this form of electricity is the natural one of the cutis vera when the body is in health and at rest :—but whatever checks the circulation of the surface,—as lassitude, cold, violent exertions, or mental anxiety,—renders the external electricity imperceptible, or gives preponderance to the negative form, which is then often apparent.

These external indications were, indeed, often so slight, as to lead to the idea that they arose from accidental causes, such as the friction of clothing on the skin ; but the careful investigations of M. J. J. Hemmer, of Manheim, have proved that a surplus of positive electricity is naturally present on the uncovered skin in individuals of both sexes. Out of three hundred and fifty-six experiments made on himself, his external electricity was found to be three hundred and twenty-two times *positive*—fourteen times *negative*, and ten times *imperceptible*.

It is to be noticed, that these observations do not apply to the frequent, and with some constitutions, the constant discharge of electricity from the feet, or, in other instances, from the hands or secreting surfaces ; such discharges being frequently carried off as currents, with no sensible accumulation which would affect the *Electrometer*.

It has been said, that the nerves are capable of increasing the vascular action of the organs to which they are distributed; and when it is remembered that, by throwing a current of voltaic electricity on the course of a nerve, we can give a tenfold activity to this stimulating influence, its great practical importance in the treatment of disease becomes at once apparent.

There is, indeed, scarcely a single case of debility from functional derangement, however confirmed by habit, or incapable of relief by medicine, in which the judicious use of galvanic means will not effect a complete restoration by a direct augmentation of the local vitality.

This agent, as we have seen, is equally applicable as it regards the blood, the circulation, and the respiratory functions; and it is a deplorable fact, that, from the general ignorance of the Profession at large, and of the Public, in these particulars, thousands are annually falling into consumption, and other forms of chronic disease, which consign them to an early grave, or entail a blighted constitution and a miserable existence.

In all cases of weakness in children, and of irregular health in young persons, and particularly in girls of languid habits, and of indifferent, or of morbid appetite, whether subject to low

Why not by galvanism also?

spirits, cough, shortness of breath, stitches in the side, pains in the head, or coldness of the feet, the use of galvanic treatment is of unspeakable advantage. It strengthens the stomach, gives power to the lungs, increases the chemical agency, while it improves the quality of the blood, and bestows that tone on the nervous system which is as indispensable to health as to enjoyment.

CHAPTER VI.

OF CERTAIN STATES OF THE LUNGS WHICH LEAD TO CHRONIC DISEASES, AND ARE RELIEVED BY GALVANIC TREATMENT.
—SINGULAR SUSPENSION OF ARTERIAL ACTION IN THE CASE OF THE GREAT JOHN HUNTER.—EMPHYSEMA OF THE LUNGS.—GRATEFUL INFLUENCE OF GALVANISM ON THE RESPIRATION OF THE AGED.—INFLUENCE OF THE MIND ON RESPIRATION.—IRREGULARITIES OF APPETITE.—DISTRESSING EFFECTS OF INDIGESTION FROM DEBILITY, WITH A PRACTICAL ILLUSTRATION OF ITS REMOVAL UNDER GALVANIC TREATMENT.

THERE are two opposite states of the lungs which are equally sure to lead to serious forms of disease unless relieved; the one is a want of blood, and the other is its redundancy. In the first case, a sufficient quantity of blood is not presented to the action of the air; and in the other, the vascular system being overloaded, the due expansion of the vesicles and tubes for the admission of air is prevented, so that the quantity respired is inadequate. An increase of local nervous energy by Galvanism is an equal remedy in both cases: it invigorates the minute branches of the pulmonary artery, so that they

urge the blood forward in the one instance, and, by the same contractile influence, prevent its accumulation in the other.

Of the degree to which the function of Respiration may be interrupted by a temporary suspension of the due Electro-Nervous Influence, we have a most curious and instructive example in an instance which occurred to the great John Hunter, and is thus related in his Life by Sir Everard Home:—

“ In the spring of 1773, having met with something which very forcibly affected his mind, he was attacked in the forenoon with a pain in the stomach, about the pylorus; it was the sensation peculiar to those parts, and became so violent, that he tried change of position to procure ease; he sat down, then walked, laid himself down on the carpet, then upon chairs, but could find no relief. He took a spoonful of tincture of rhubarb, with thirty drops of laudanum, without the smallest benefit. While he was walking about the room, he cast his eyes on the looking-glass, and observed his countenance to be pale, and his lips white, giving the appearance of a dead man; this alarmed him, and led him to feel for his pulse, but he found none in either arm. He now thought his complaint serious; several physicians of his ac-

quaintance were then sent for; Dr. William Hunter, Dr. Saunders, and Sir William Fordyce, all came, but could find no pulse; the pain still continued, and he found himself at times not breathing. Being afraid of death soon taking place if he did not breathe, he produced the voluntary act of breathing by working his lungs by the power of the will; the sensitive principle, with all its effects upon the machine, not being in the least affected by the complaint. In this state he continued for three quarters of an hour, in which time frequent attempts were made to feel the pulse, but in vain; however, at last the pain lessened, and the pulse returned, although at first but faintly, and the involuntary breathing began to take place. While in this state, he took Madeira, brandy, ginger, &c. but did not believe them of any service, as the return of health was very gradual; in two hours he was perfectly recovered."

There can be no doubt, but that the artificial respiration in this instance was just enough to keep up that slow exchange of circulating fluid, which prevents the coagulation of the blood, as is the case in swoons, and in the instance of hybernating animals;—John Hunter survived this extraordinary attack twenty years.

A languid, and inefficient vascular action,

eventually leads to a state of Emphysema of the Lungs; a condition, in which the air cells remain permanently distended; and the due exchange of air not taking place, asthmatic symptoms of the worst character ensue,—and the general indications of a broken-down constitution are soon apparent. In severe cases, the shoulder-blades and collar-bones become permanently raised, and as the parietes of the chest do not properly collapse in respiration, the function of breathing is almost entirely effected by the diaphragm. The vesicles around the borders of the lungs are the principal site of this disease; and after death, these emphysematous portions appear almost entirely devoid of blood, dry, and pallid: indeed, so completely is the capillary circulation suspended, that the obstruction of the fine branches of the pulmonary artery frequently leads to an enlargement of the right cavities of the heart; while, with the enfeebled flow of blood, the animal heat is materially lowered. Unfortunately, there is strong reason to conclude that this disease is of an hereditary character, as the investigations of Mr. Jackson have shown, that of twenty-eight persons suffering from emphysema, eighteen were the offspring of parents who either on the one side or on the other had been so affected.

Now, this is a disease, which every honest man must confess to be altogether beyond the reach of medical aid, in the ordinary sense of the term ; and yet, it is one in which much may be expected from galvanism, when the structural change is not far advanced ; while even, in the worst instances, the general strength of the patient may be very much supported by proper electrical treatment at intervals. In favourable instances the vascular system of the lungs receives an invigorating influence from galvanic excitement ; but, in the confirmed cases, the benefit conferred is undoubtedly owing to the increased capacity for the absorption of oxygen, which the presence of voltaic electricity bestows upon the blood ; and which renders the imperfect respiration imposed by the disease of less importance. This result may be rendered evident, by referring to the experiment tried by Sir Humphrey Davy on carbon, in which it appeared that when made part of a galvanic circuit, carbonic acid gas was given off at the positive pole, and carburetted hydrogen at the negative. It is on this principle, that gentle galvanic applications in the form of *quantity* are so grateful to the aged and the weak : the extra carbon, with which the circulation was oppressed, thus finds a more ready exit by respiration ; a

more highly vitalized state of the blood is the result ; and a feeling of renewed power pervades the system.

In speaking of Emphysema of the Lungs, as causing the worst form of asthma—and one which, in its mature state, involves great structural change, and is consequently incapable of cure—it is of the first importance to distinguish it from other forms of asthma, which when understood, are commonly called nervous or spasmodic ; and as they arise from a sympathy between the respiratory nerves and those of the stomach, are very readily acted upon, and irradiated by the due galvanic treatment.

Such, undoubtedly, were the striking cases of Asthma so successfully treated by Dr. Wilson Philip ; and here it is to be particularly noted, that the most confirmed cases are susceptible of relief, and that the improved character of the respiration is lasting. Dr. Wilson Philip writes as follows :

“I have employed galvanism in many cases of habitual Asthma, and almost uniformly with relief. The time during which the galvanism was applied before the patient said that his breathing was easy, has varied from five minutes to a quarter of an hour.—The cough under its use generally becomes less frequent

in proportion as the accumulation of phlegm in the lungs is prevented.

It is remarkable, that in several who had laboured under asthmatic breathing for ten or twenty years, it gave relief quite as readily as in more recent cases. The permanency of the good effects of galvanism in the disease before us has appeared very remarkable."

The Digestive Functions, as we have observed, are implicated in this form of Asthma; and a more healthy state of these organs always accompanies its removal. There are, however, very many affections of the Stomach, where no direct sympathy with respiration takes place, and in which galvanism is by far the most efficient remedy:—and, this is particularly the case, when, from having undergone long courses of the usual medical treatment, the repeated use of drugs has impaired the animal powers, and deprived the general health, until all nervous tone is lost, and existence becomes a blank.

The two greatest advantages which humanity can boast, the possession of superior mental endowments, and the command of fortune, not only render men the more prone to fall the victims of this wretched doom, but, at the same time, make them more sensitive to the tortures it inflicts. Close study and sedentary habits

are familiarly known to entail these penalties ; but one of the first injurious consequences of intense thought, has been very little known until it was pointed out by Dr. Marshall Hall in his able work on the Nervous System. I mean its influence on respiration. No sooner does a man begin to think deeply, or to devote his attention to some mechanical act that requires great caution, than he may be observed to breathe slower ; and often, if he meets with an unexpected difficulty, to suspend his breath entirely : even the more gentle emotions, as they absorb the mind, lead to the same result. Of this all our best authors have been aware ; and who does not remember the simple yet eloquent lines of Sir Walter Scott :

“Those silv’ry tones so soft, so clear,
The listener *held his breath* to hear.”

“And thus,”—as Shakespeare says :

“— the native hue of resolution
Is sicklied o’er with the pale cast of thought.”

And so it is, that too much sedentary occupation soon robs the female cheek of its natural bloom ; and that the closely toiling artisan becomes, too often, feeble and sickly in the flower of his age.

With impaired Respiration, a loss of the due

Electricity occurs; the arterialization of the blood is impeded, and with this loss of Vital Force the process of Digestion is enfeebled. With some individuals the appetite is keen, but easily satisfied, for the weak stomach cannot bear much, and becomes oppressed with a little; but this little is not sufficient to support the system, and so an irregular craving comes on, and the man eats, and eats, and yet is comfortless,—for the constant and inefficient action of the digestive organs begets a restless uneasiness of mind. Another eats at first with little zest, but feels his appetite improve as he goes on, and from this false feeling of strength in the excited stomach, he swallows twice as much as the gastric juice can properly affect, and so his stomach remains overloaded, with its muscular coats relaxed by extreme tension, and all his senses in a state of lethargic heaviness. It were tedious to point out the maladies which ensue from these common-place forms of indigestion;—there is hardly any ill “that flesh is heir to” that may not claim alliance with the one or with the other,—and the self-indulgence of the wealthy and luxurious often involves them in all its strange variety of forms.

But there are other causes of indigestion, with results that are equally tormenting. Of

these, some of the most frequent and injurious are the artificial habits of society, and the calls of professional duty, when they run counter to the constitutional powers of the individual. Late hours for food and rest often arise from both these causes, and are most prejudicial to persons of delicate stamina, or those whose constitutional strength has been impaired by close application, too much excitement, or irregularities in early life. In all these cases debility is present;—debility of stomach; debility of muscular and vascular action; I had almost written, debility of mind,—for there is always an inertness that checks intellectual exertion, and often a feeling of irritability but ill repressed.

A man so suffering, will rouse himself on the spur of the moment to an appearance of alacrity; will, for the time, be earnest in business, or gay at the social board; but this is but as the sunny gleam of an April day, which has not power to excite a genial warmth in the atmosphere, but glitters for a moment and is gone, leaving all more chill and cheerless from the contrast. So, these transient rallies of exertion leave the individual yet more depressed;—they are but as the sudden flares of the exhausted lamp, that burns again, but the more dimly, for the previous waste.

One of the most annoying circumstances attendant on indigestion from general debility, is the consciousness which a man feels of physical depression which does not externally appear, so that often to himself, and still more frequently to others, his real weakness seems but the product of a diseased imagination. Hypochondria follows; and then with the usual treatment for nervous maladies, and the usual round of boluses and draughts, he falters on and wastes from day to day, becoming soon the shadow of his former self,—living by rule, self-mortified in very fear, with the rigour of an anchorite,—or phrensied with the strange thoughts and groundless terrors which are engendered by exhaustion, he mopes into madness, or seeks relief in suicide.

Indigestion from general debility, in some instances, comes on in very early life, in the most distressing form. I have now before me a long description of a case of this nature, furnished by a gentleman who was my patient, in attestation of the restoration of his health from galvanic treatment. He was twenty-two when he first consulted me, and had suffered from indigestion and dyspepsia for three years, notwithstanding all the assistance, which liberal means, with the most anxious desire and active exertions to obtain it, could command; for when he found him-

self no better for the advice received in London, he went to Paris—but still the disease continued.

The advice obtained too, was of the first class; among other leading physicians, Dr. Chambers was for some time consulted, so that all the usual means were tried, under the direction of great professional skill and judgment; but they were tried in vain;—the case was beyond the reach of the ordinary resources of medical science.

When I first saw him, there was a languor and debility shown in every feature, and in every movement, which contrasted painfully with what, it was apparent, would otherwise have been in a high degree, a frank and manly bearing.

A wretched prostration of the spirits occurring at intervals, is one of the most common marks of nervous debility when combined with indigestion, and in this instance, these symptoms had been severely felt. There was too, what the patient himself termed “a drawn expression of countenance,” which was occasioned, by a constant soreness felt at the pit of the stomach, that increased to a distressing sense of pain on the least pressure. This symptom, which had then existed without intermission for a period of upwards of three years, was so strongly marked, that there could be little doubt but that a vascular turgescence had occurred, which threatened an or-

ganic disease that would probably take on the cancerous character if not removed. This view was strengthened from the existence of two considerable pustules on the back of the tongue, in that state of vascular turgescence which constitutes incipient inflammation.

This was a most serious form of disease, and its importance had evidently been duly weighed by the medical authorities before consulted; but the patient believed that the strange mistake had been committed, of making a scape-goat of the Liver, and thus leaving the Stomach unsuspected. He writes as follows:—

“Every body I had consulted agreed that I was labouring under a chronic disease of the Liver, and the remedies prescribed by the Pharmacopæia were brought into full play on that most unfortunate gland. To this observation you will probably assent, when I tell you that during the year 1840 I underwent the martyrdom of *One Hundred and Twenty Leeches—Four Blisters—One Bleeding, and Two Severe Courses of Mercury!* And after all, where do you think the pain—this torpid liver pain, was?—Where?—Why, where it had been in November 1837, and ever since, at the pit of the stomach!”

It would perhaps have been difficult to have found a case better calculated to test the power

of galvanism as a constitutional remedy, and I must confess that I felt considerable anxiety, both as it regarded the welfare of my patient and on professional grounds. Nor did it seem for some time that this anxiety was likely to be allayed, for the most careful application of Galvanic treatment to the vascular system, and the digestive organs, though it improved the general health, and inspired greater constitutional vigour, left this "gnawing soreness" exactly as before; and the very fact of getting better in other ways seemed but to render the patient more wretched in this then almost hopeless particular.

Under this exigency, I became most anxious to concentrate the Electrical Force as far as possible on the Stomach; and for this purpose, I found it necessary to invent an apparatus by which the *lateral discharge*, and the waste by evaporation—occurring from the use of sponge, or other arrangements when moisture is present in the conducting connections—was avoided, and the whole force divided into many separate streams, was collected in a circular form and thrown on the surface, so as to overcome the resistance of the dry epidermis, and to penetrate at once to the coats of the stomach. In these applications, the *positive* pole was directed sometimes to the cervical vertebræ, and at others

near the spleen ; and occasionally, from side to side, that the electrical currents might pervade the stomach from one extremity to the other. The commanding effects obtained by this new apparatus were at once apparent, in the activity given to the capillary circulation, as shown by the redness of the skin, and a profuse perspiration thrown out locally ; and which was so great as to soak through the velvet, covering the centre of the disk in the new instrument in three or four minutes. The salutary influence was equally decisive. The first indication was a renewed power of contraction in the stomach, which had before a peculiar and uneasy feeling of distension. This was immediately followed by a recession of the pain,—and after the fourth application, I had the satisfaction of finding that a clear intermission of the pain for half-an-hour had occurred.—The patient writes as follows :

“I began to feel decidedly good effects, and after the fourth, I was greatly rewarded by a decided intermission for a clear half-hour. I wish to observe most pointedly in this place, that, that one half-hour was the first intermission that I had enjoyed since Nov. 1837, and I must be allowed to say, that here was a remarkable effect produced :—the application of Galvanism for the space of three weeks had re-

moved a pain which had existed for an equal number of years."

The same treatment was continued, and the intermissions became rapidly longer, and more frequent, until the pain was entirely gone. In the meanwhile, the patient had gained an additional weight of *four pounds*; and having been under my care for three months, he was in every sense restored to the energy, strength, and buoyant spirits, that so delightfully characterize his time of life,—and I have the pleasure of adding, that this restoration has been as permanent as it was complete.

CHAPTER VII.

COMPLICATED FORMS OF INDIGESTION.—OF THE “THERMO-CHRONIC SYSTEM,”—COMMON, BUT FALLACIOUS MODES OF TREATING INDIGESTION.—PECULIAR EFFICACY OF VOLTAIC ELECTRICITY IN DISEASES OF THIS CLASS, WITH PRACTICAL ILLUSTRATIONS.—OF THE NATURAL ELECTRICAL CONDITIONS OF CERTAIN INTERNAL SURFACES AND ORGANS.

IN the more common forms of Indigestion, in addition to great and distressing irregularity of nervous action frequently causing Dyspepsia, with diseased secretions of the Stomach,—there is also, more or less, direct functional derangement of the liver, and of the bowels: and in these instances, we have not only that sympathetic reaction on the brain, that renders every local injury, more or less, a disease of the *whole system*, and is the origin of those Electrical Revulsions, between the capillary circulation, and that of the heart, which are attended with alternate *hot and cold sensations*, and are, in fact, the leading symptoms of intermittent fever, only differing in degree of intensity, and which have thus formed the foundation of Dr. Dickson’s important views in the “Thermo-Chronic System:”—But in the disease before us,—we have, as we have

said, something more. It is a complication of several local forms of positive disease; and each so far distinct, as to admit of alleviation in itself. This last fact is of the first importance, for it has been the foundation of that fallacious, and patching up plan of medical treatment, which is at first flattering, but ultimately most pernicious to the patient suffering from indigestion.

Thus, when the stomach, liver, and bowels, are all affected; if, with such views, you act upon the liver, in the usual way with mercurials;—with the increased flow of bile, the bowels are relieved and the patient feels better. But the evacuations have produced more or less debility, and if the patient takes cold, or makes the slightest *error* in diet, or, often if the weather only changes,—all is again as bad as ever; and indeed, worse; for now the course of medicine for the liver must be heavier than before, and the subsequent debility will be greater.

Then on the other hand, if the main attack is made on the bowels; relief is still obtained; and often with less debility; but it is enjoyed only for a short period; and each time that the medicine is repeated, this interval is lessened, as the bowels become more and more torpid, under the reaction from stimuli.

Again, if the stomach is roused into a state of greater activity, by *Quinine*, or other tonic agents, the Patient may feel better for a time ; and may even fancy, that he is getting well all at once ! until the over excitement and strain upon the system brings on constipation of the bowels, with enlargement or inflammation of the liver.

But say, that these different modes of treatment have been so skilfully combined, as to strengthen the stomach, stimulate the liver, and liberate the bowels,—still, the relief is obtained, on principles that relax the general system, and so the weakness in which the disease originated is gradually increased by the remedies employed to remove it, and the symptoms will return to be again, but only for a time, subdued.

The fact is, that drugs may palliate, but can never cure, this form of Indigestion. The disease arises from a want of the vital electricity which drugs cannot supply, as they only act by producing *accumulations*, and a consequent expenditure of the constitutional electricity of the Patient, already at too low a standard.

The cure for this complicated, and common form of Indigestion, it need not be added, can only be the Natural, or the Artificial:—but, it may seem strange when we add, that when properly understood, both are found to be the same.

The first, is the increased accumulation of Electricity by natural means ; and is only to be produced in the early stages, and under favourable arrangements, while the party retains considerable strength, has a command of time, and circumstance, and possesses great perseverance ; for it is the result of a constant habit of long continued and energetic exercise, with the concomitants, of regular hours, pure air, cheerful thoughts, and a varied and nutritious diet taken at easy intervals.

The Artificial, is Galvanism ;—and in no instance is this commanding remedy more decisive in its action. The salutary agencies of Voltaic Electricity on the blood, on the respiration, and on the nervous system, are all of service here ;—but it has other powers, which are of the most essential importance, and for which, no equivalent or substitute can be found. These are, the augmentation of the gastric juice, as proved in the experiments of Dr. Wilson Philip ;—the increased vigour given to the peristaltic action of the bowels, which is very considerable, and became apparent to the eye in a case of hernia, where there was external ulceration, exposing the intestines of a patient under the care of Dr. Archard of Berlin :—and thirdly, the great results produced on the Liver ; a renewed activity

pervading its circulation; while the secretion, fluidity, and discharge of the bile, are all augmented. In writing on this subject Dr. Wilson Philip remarks :

“I have repeatedly seen from it, the same effects on the biliary system which arise from calomel; a copious bilious discharge from the bowels coming on a few hours after its employment.”

It is of importance to remember here, that the secondary influences of Galvanism, when used in the relief of Indigestion, are happily, exactly the reverse of those arising from medicine; for instead of the debility, and insidious waste of constitutional force following the use of drugs, an augmented power is bestowed, which gives stability to the other advantages obtained.

In no case, is it more essential to vary the character of the galvanic applications, both as to quality and power, than in the treatment of indigestion. In many instances Voltaic Electricity, in its different forms, is in itself a sufficient remedy; but in others, I have found it advisable to employ it in combination with small doses of medicine in the first instance, and afterwards alone.

The rapid amendment of the patient under this compound treatment has been, in several in-

stances, most remarkable, and it is only to be accounted for, by the great additional chemical agency, which some forms of medicine acquire when the digestive organs are placed in a high Electro-Tonic state.

One of the most signal instances of this sort, that I have had the satisfaction of observing, was that of a gentleman who had been a victim to the compound form of Indigestion, of which we are now treating, for no less a period than ten years; and who, when he first consulted me, very candidly remarked, that he had done so "as a forlorn hope," his constitution being, as he imagined, so habituated to an irregular course of action, as to be incapable of amendment,—and all medical advice having been hitherto in vain.—In this latter particular, it certainly appeared that there had been no want of exertion; he had undergone long continued courses of medicine, under the care of leading physicians; he had travelled on the Continent, and had afterwards resided at Lemington, where even the advantages of good air, the saline spring, and regular exercise were unavailing. He was then confined to a simple and uniform regimen, which was taken without appetite, and to which he had found it necessary to adhere so rigidly that he never thought of dining out:—And yet with every

possible care, he was subject to the most severe effects of Indigestion;—Dyspepsia, head-ache, giddiness, torpor of the liver, and of the bowels, —feelings of exhaustion, a dry skin, with a tendency towards nervous irritability, and a great want of sleep. As these latter symptoms betokened an irregular state of the capillary circulation in the membranes of the brain, the galvanic treatment, in this case, was directed so as to equalize the general circulation, and increase the insensible perspiration of the extremities.

Fortunately, the desired impression on the vascular system was so far obtained by the first application, that the patient told me the next morning, he had slept better than for many previous months, and felt an unusual degree of appetite and strength. The Galvanic application was then repeated, and directed so as to affect the liver; and the patient was desired to take one grain of blue pill, with half a grain of the hydriodate of potass at night, and to keep in the house the whole of the next day, as it was probable that the bowels would be very much affected, which on the succeeding morning the patient said had been the case, to what he deemed, a very extraordinary degree; great quantities of bilious matter having been thrown off; but what most surprised him was,

that instead of those uncomfortable feelings, and that prostration of strength, which he had found to accompany all such evacuations in previous instances, he had on this occasion felt no sort of inconvenience; but on the contrary, a lightness of body, and a cheerfulness of spirits, to which he had long been a stranger.

The Galvanic Treatment was then again varied, so as to bestow increased Electro-Nervous Force, to stimulate the stomach, and give a tone to the peristaltic motion of the bowels; and as the appetite became keen, and regular, the patient was directed to throw aside all the previous restrictions in diet, and merely to confine himself to plain and nutritious food with a few glasses of wine. On this plan of treatment he appeared to gain additional strength with each succeeding day;—the bowels were regular; the sleep refreshing; and the appetite good; and, in fact, he was, “to all intents and purposes,” as he himself said—“a new man.”

The galvanic applications in this case were only nine; and the restoration has been permanent.

I have had several other instances in which the influence of Galvanic Treatment on the liver and bowels has been both rapid and salutary in a high degree; and in one, a female case, where

a loaded condition of the liver had produced cough, shortness of breath, and pain in the side, which had long continued without relief from the usual cough medicines, and were attended with a bad state of the *Uterine* circulation,—all the symptoms were at once subdued, by one well-timed application of the Voltaic Electricity of *quantity*; the desired effect being thus produced upon the liver, bowels, and *circulation*; and the patient relieved from a state of suffering, which would probably have ended in consumption.

Having so far explained the practical results to be obtained from the careful and efficient use of Galvanism in cases of Indigestion, it may be useful to consider the Electrical conditions which are natural to the internal Organs, and Surfaces, of the Human Body, and which are essential to the process of assimilation.

Nothing can be more amusing, than the dilemma into which this portion of our subject has thrown that phalanx of scientific men, whose previous prejudices have rendered them unwilling, or incapable of admitting the force of evidence which places Electricity in the first rank as a Vital Influence. Thus they admit, on the evidence of Davy, and of Faraday, with a host of other Authorities, that all chemical

changes are essentially Electrical ;—and since it is as certain, that the changes of the air in the lungs, of the food in the stomach, and of the animal fluids in secretion, are all of a chemical character ; it follows that they must also be Electrical :—but then comes the question, which involves these gentlemen in a practical absurdity—are these chemical changes going on within the body, effected by the agency of its own Electricity ?—or does the Electricity inseparable from such changes arise in the matters changed as a secondary product ?

Or, to put the question in a still more simple form ;—is milk, when taken into the human stomach, coagulated and changed by the Electrical powers of the Stomach ?—or, does it coagulate by its own Electricity ?—This latter hypothesis cannot be the fact, or the milk would have been coagulated before it was swallowed ! and they are also aware, that if it were so, the whole process of Digestion would be secondary to the laws of inanimate matter, and the Stomach itself would be as passive as a leathern bag, in which the fermentation and putrefaction of vegetable and animal matters would spontaneously occur, and defeat all the purposes of assimilation. It has, therefore, been very generally admitted, even by those who deny the entire

Physiological agency of Electricity, that still, the Digestive Organs do act on Galvanic Principles.

The following conclusive arguments on this view of Digestion are quoted from the *Bridge-water Treatise of Dr. Prout*, and appear in the Section containing the "CHEMISTRY OF ORGANIZATION:"

"The aliment having been previously broken down by mastication, and having received an admixture of saliva and of other fluids, is brought into contact with the fluid secreted by the stomach; by this secretion of the stomach, or by some other energy exerted in that organ, the food, which has been introduced into the stomach, is associated with water; and thus becomes itself more or less fluid. Of this important secretion of the stomach, *chlorine*, in some state or other of combination, is an ingredient: it would seem a necessary ingredient; for the secretion in its healthy state always contains more or less of *chlorine*; the powerful influence of which elementary principle seems mainly to contribute towards effecting the union of the food with water. The *chlorine*, thus so indispensable to the reducing process, is perhaps more frequently the subject of derangement than anything concerned with the assimilation of

the food. It often happens that instead of *chlorine*, or a little free muriatic acid, a large quantity of free muriatic acid is elicited; which free muriatic acid not only gives rise to much secondary uneasiness, but more or less retards the process of reduction itself. The source of this *chlorine*, or muriatic acid must be the common salt which exists in the blood. The *chlorine* is therefore secreted from the blood; and it may be demanded what is the agency capable of separating *chlorine* from a fluid so heterogeneous as the blood? We are acquainted with *one agent* that exerts such a power, namely ELECTRICITY. *** But here the question arises—What becomes of the soda from which the muriatic acid has been disunited? The soda remains behind, of course in the blood, and a portion of it, no doubt, is requisite to preserve the weak alkaline condition essential to the fluidity of the blood. But the larger part of this soda is probably directed to the liver, and is elicited with the bile in the duodenum; where it is thus again brought into union with the acid which had been separated from the blood by the stomach.

“These observations illustrating the importance of common salt in the animal economy seem to explain in a satisfactory manner, that

instinctive craving after this substance which is shown by all animals.

“Admitting that the decomposition of the salt of the blood is owing to the *immediate agency* of GALVANISM; we have in the principal digestive organs *a kind of Galvanic Apparatus*, of which the mucous membrane of the stomach, and perhaps the mucous membrane of the intestinal canal generally, may be considered as the acid, or *positive pole*; while the hepatic system may, on the same view, be considered as the alkaline, or *negative pole*.”

It will be observed that the chemical facts here mentioned are such as will not admit of any other conclusion but that the reciprocal agencies of the Stomach, the Liver, and the Intestinal Canal, are essentially GALVANIC;—and it is a very singular proof of the force of prejudice, that this truly learned author should not have carried out the deductions arising from this, his own able demonstration of the Electrical Character of the function of Digestion; deductions which are, indeed, as we shall presently see, almost self-evident, and of much practical importance. Instead of this, it however appears that he has unfortunately terrified his imagination with the untenable theory that ascribes the electricity of the human body to some preter-

natural connexion of that fluid with the nervous system, as he says in the same Section, "that mere nerves are not sufficient to develop electricity." Most certainly not,—for the bare assumption would involve the absurdity of supposing that Electricity may become *an animal secretion*, to be produced in the nerves without the agency of the glands, or of the circulating fluids.

CHAPTER VIII.

RESPIRATION AND DIGESTION VIEWED AS RECIPROCAL AGENCIES.—TWO PRIMARY DISTINCTIONS IN THE CHARACTER OF FOOD.—GALVANIC INFLUENCE ON THE SYMPATHIES OF THE PNEUMO-GASTRIC NERVES.—COMBUSTION THE RESULT OF RESPIRATION.—PHYSIOLOGICAL LAWS GOVERNING THE CONSUMPTION OF FOOD.—ACCUMULATION OF ELECTRO-FORCE FROM THE TRANSFORMATION OF THE TISSUES.—THE USE OF OXYGEN DEPENDANT ON ITS ELECTRICAL AGENCY.—LIFE DEPENDANT ON RESPIRATION AS THE MEANS OF GIVING ELECTRO-TENSION TO THE BLOOD.—ANIMAL HEAT THE PRODUCT OF ELECTRICITY.—ELECTRO-IMPULSION OF FLUIDS.—THE ANTISEPTIC QUALITY OF THE LIVING TISSUES DEPENDANT ON ELECTRO-ACCUMULATION.—MISTAKEN VIEWS OF PROFESSOR LIEBIG ON THE ABSORPTION OF THE GASES.—REAL CAUSES OF DEATH FROM THE EXTRICATION OF GAS.

IN speaking of Digestion, it is necessary to remember, that part of the food which in this process is so dissolved and changed by the Galvanic Agency of the stomach as to be capable of assimilation with the blood, is indispensably necessary to support the function of Respiration ;—while another part is destined to afford fresh materials to the solids of the animal frame. A knowledge of this *reciprocal agency*

of the functions of Respiration and Digestion is of great practical importance, as it opens to our view the only philosophical rationale for the use of Diet which can enable us to employ it as a secondary agent in counteracting those irregularities of Vital Action which constitute disease; and this it accomplishes in its degree with absolute certainty and great simplicity; for however varied the articles of food may be, they have in this sense only *two characteristics*, the one class including the *carbonaceous* compounds essential to, and consumed in, the function of Respiration, and in the formation of fat,—and the other the *nitrogeneous* compounds essential to the formation of the muscular fibre.

The *reciprocal agency* of these leading functions is, again, of great practical importance, when considered in reference to the application of Galvanism as a medical agent; for by stimulating the Digestive organs when in a state of debility, it frequently happens, from the sympathies of the pneumo-gastric nerves, that the Respiratory Functions are improved:—and on the other hand, where those functions are weak, while an undue avidity for food is manifested, both irregularities may often be relieved by stimulating the action of the lungs; the blood at the same time obtaining, with its increased

Electricity, an augmented chemical power for the absorption of oxygen and the extrication of carbon.

The discharge of carbonic acid gas from the lungs, as the result of Respiration, had long since led to a knowledge of the fact that, that function is in itself, nothing less than a species of combustion;—and it is now known that, by this process, the oxygen of the atmosphere is combined with the carbonaceous constituents throughout the body, and that Animal Heat is the result. But the possibility of showing that the quantity of carbonic acid thrown off is in direct proportion to the quantity of carbonaceous matter received into the stomach, was first proved in “*An Essay on Food*,” by W. Grisenthwaite, Esq. published in 1838. At page 17, this author remarks:—

“According to the Atomic Theory, or the Theory of Definite Proportions, carbonic acid is composed of two atoms oxygen, and one atom carbon; or, by weight, of two parts oxygen and 0.75 parts carbon. Now 40,000 cubic inches of carbonic acid gas will, upon calculation, be found to weigh 18,600 grains, of which 5,070 grains are pure carbon, or rather more than *eleven ounces and a half* avoirdupois weight; all of which are derived from the blood in the course

of twenty-four hour's Respiration."—"It is manifest, that the body itself could not sustain such a loss for any great length of time. In about ten weeks, or a fraction more, a man weighing one hundred and forty pounds avoirdupois would vanish into thin air, or be reduced to vapour;—for in that period all his carbon would be consumed by Respiration; and we shall not stop to speculate on the appearance he would make, when composed of oxygen, hydrogen, and nitrogen only, even if we left him with his 'bones marrowless' and ungelatinized."

Mr. Grisenthwaite proceeds to show, that the amount of food necessary to supply this consumption of carbon in the function of Respiration during twenty-four hours would be twenty-six ounces of flour, which is equal to about thirty-five ounces of bread;—or six pounds and a half of potatoes;—or four pounds and a half of (muscular fibre) fresh meat.

I have quoted this passage, as the same views have been recently brought before the Public in the "*Animal Chemistry*" of Professor Liebig. After proving the point in question with an overwhelming mass of evidence, this great Authority observes, page 95:—

"The substances of which the food of man is composed, may be divided into *two classes*, the

nitrogenized and the non-nitrogenized:—the former are capable of conversion into blood, the latter incapable. The nitrogenized, may be termed the Plastic Elements of Nutrition,—the latter, Elements of Respiration. Among the former, we reckon Vegetable Fibrine, Vegetable Albumen, Vegetable Caseine, Animal Flesh, Animal Blood. Among the elements of Respiration in our food are—Fat, Starch, Gum, Cane-Sugar, Sugar of Milk, Pectine, Bassorine, Wine, Beer, Spirits.”

It will be observed that, in the *reciprocal* actions of Digestion and of Respiration, two direct means for the accumulation of Electricity are supplied. First, in the solution of the food in the stomach, when the active force derived from the Positive Electricity of the blood leads to a disorganization of the alimentary substances, with the extrication of more or less *free* Electricity:—and Secondly, the combination of the oxygen of the air, with the iron of the coloured globules of the blood; and the formation of carbonic acid gas throughout the system with its evolvment in the lungs during Respiration; both of which processes leave a surplus of Positive Electricity.

Again, it is to be noted, that, in the exercise of both functions, a demonstration of Heat oc-

curs, but with this marked difference, that the increase of temperature in the stomach during Digestion is not the immediate result of combustion; while, in the instance of Respiration, all the phenomena are nothing less, either in regard to the direct changes effected in the lungs, or to the secondary, but equally important ones occurring throughout the body on the union of the extra oxygen of the arterial blood with the carbon and hydrogen of the organic tissues and fluids; that union being the actual *burning* of those animal constituents, which are thus transformed into carbonic acid gas, and into water, precisely as they would have been if consumed in the open air.

The explanations of Liebig on this subject are of the most luminous and convincing character; and never, perhaps, has Truth appeared in a more simple or resistless form. In the first instance, he shows that, in no part of the animal body, is iron a necessary ingredient, except in the coloured globules of the blood; and that, as this iron is not destined to any purpose of nutrition, by becoming part of the animal frame, it has evidently some other office; and this he proves to be, first, the absorption of oxygen from the air, which oxygen is again absorbed by the animal solids from the arterial blood, and by

these solids again rendered up, to be absorbed by the venous blood, in combination with carbon, as carbonic acid gas.

Thus, the absorption of oxygen gives the intense crimson to the arterial blood in the lungs; which colour becomes dark, and ultimately changes to the purple of the veins, in the capillary circulation, where the oxygen is absorbed by the muscular fibre, which, as Liebig states, in a chemical sense, is nothing more than blood in a solid form. It is with the *carbonaceous* portion of the muscular fibre that the oxygen thus unites, as it does also, with the constituents of fat in a less degree, and under certain circumstances: all these are combustible bodies, and a portion of all, are constantly in a state of *low ignition* in every part of the animal frame at the same instant of time,—and so constitute that all-pervading vital fire, rendered sensible as “*Animal Heat*,” and which is essential to the fluidity of the blood, and to the continuance of Organic Life.

As in every other instance of *combustion*, the carbon of the animal body is, so far as it unites with oxygen, converted into *carbonic acid gas*, which, being absorbed by the veins, is carried to the lungs, and so thrown off; the loss of carbon, &c. being supplied by the food, which

in this sense, as Liebig rather quaintly observes, —is nothing more than so much *fuel* thrown on a furnace fire !

But in this simple and *continuous* formation of carbonic acid gas throughout the System, a fact arises of the first importance, as it regards Electro-Physiology ;—for, by the well-known chemical law, that on its formation, this gas assumes the *positive* form of Electricity, we have at once, an explanation of the mode in which that vivifying agent is constantly and efficiently supplied ; and that under circumstances that admit of no material impediment or delay without the immediate loss of Life.

Of the distribution of the Positive Electricity, much has already been said. Its surplus passes from the blood, in the first instance, by induction in a variety of ways, and becomes the agent of the vital chemistry of digestion and of secretion, and the exciting cause of muscular contraction, and of nervous energy. At the same time, the carbonic acid gas thrown off by the lungs, has its remaining Positive Electricity so much absorbed by the moist passages through which it passes, and so far neutralized by the Electro-Negative character of the watery exhalations by which it is accompanied, as to be very slightly indicated in the strongest individuals ; and, in

the majority of instances, so completely lost, as to give way to the Electro-Negative state in a confined atmosphere, as observed by Reid.

In the animal body, the amount of Vital Electricity so generated varies in proportion to the capacity of the lungs ; the quantity of Respiratory food ; the size of the individual, and the power of Electro-Retention ; so that the sum total, if measured by the volume of oxygen inhaled, or by that thrown off as a constituent of the carbonic acid gas, is uncertain : but some idea may be formed, from what occurs during the respiration of plants, which bears an analogy, Pouillet having shown, that the surplus electricity arising from a verdant area of a hundred yards square, is sufficient to charge a powerful battery.

How true is the popular language, that Breath is Life ! And again, how true is the theory of John Hunter, in accordance with Holy Writ, that the Life is in the Blood ! But let us look a little farther, and inquire how these truths are realized. We know that the vitalizing constituent of the air is its oxygen ; and that without it, we have no means of existence. But how does the oxygen support us ? We shall see that it cannot do so by itself, but only by its agency :—nay more, as Liebig has shown, oxygen is the

great agent of corrosion, and of that combustion which is constantly consuming our very substance; and transforming this solid corporeal frame into thin and unsubstantial air!—and that for this very purpose it is imbibed by the iron of the blood, and distributed throughout the entire System; but it is not received to be retained;—for although, as the experiments of Lavoisier have shown, a man actually takes into his system from the atmosphere *seven hundred and forty-six pounds* of oxygen in a year,—yet, at the close of that period, he may not be one ounce the heavier than at its commencement. The oxygen was only received, to be the agent for the transformation of certain constituents of the body. Is, then, the carbonic acid gas, into which it changes, a resource for animal nutrition, or a stimulus to animal existence? No—it is neither:—but if retained, it would be in itself a fatal poison! How, then, we demand,—since the oxygen, in the first instance, is the agent of destruction, and, in the second, part of a compound of a deleterious character,—how can it infuse a vivifying influence? How, in the popular language quoted, can it be the Life in the Breath—or in the Blood?

This seeming paradox admits of but one answer,—and that is, that oxygen is essential

to Life, only as it is the direct means of producing an evolvment of ELECTRICITY, and of distributing that Vital Agent, in accordance with the laws essential to the cerebral, nervous, and vascular functions on which existence depends.

This great fact suggests a question of equal moment with the last. An evolvment of Electricity being the result of the chemical arrangements thrown into action by Respiration,—what are the immediate phenomena to which that Electricity gives birth? We answer, that the first is Vital Heat, which is continuously evolved throughout every portion of the animal system at the same instant of time, and is the result of *the union of the two electricities*,—a physical law which becomes evident, from the following simple and conclusive experiment, first made at Guy's Hospital by Thomas Smith, Esq. of Maryport:—

Coat the bulb of a delicate air thermometer with tin-foil, and connect it with the conductor of an electrical machine in a state of action. In this connexion, silent discharge takes place from the coated bulb as its overplus of *positive* electricity combines with the *negative* electricity derived from the surrounding medium, and the generation of *heat* at the same moment is immediately shown, by the fall of the coloured fluid

in the tube from the expansion of the confined air,—the fall being frequently upwards of an inch.

The second portion of our answer involves questions of a more intricate character, as it relates to effects, immediate, relative, and distant. The immediate, are the chemical affinities created by the Electrical Forces, and presiding in secretion, and in the process of digestion. The relative, are the impulsive movements created by the Electrical Attractions, as in the instance of a fluid being impelled towards the negative pole when forming a portion of a Galvanic Circuit. This phenomenon is of practical importance in the treatment of disease, and is demonstrated by the following experiment:—Divide a vessel into two compartments by a partition of animal membrane; let the one compartment be nearly filled with water, while the other is only partially so; connect the Positive Pole of a Galvanic Battery in action with the full one, and its Negative Pole with the other; and the water will now be seen to rise in the one, and to sink in the other; until the one which was almost empty, and furnished with the negative wire, is nearly filled.

The distant, or influential, is the power of Electricity as conducted by the nerves; as in the

instance of muscular contraction ; and in such cases, the Electrical Agency of Organic Life is so far identified with that of external nature, that by throwing an artificial current of Electricity on the principal nerves of an organ, we can produce the most energetic movements independently of the will of the individual. Thus, by the Electrical excitement of the diaphragm, we cause violent and involuntary laughter in the most grave and self-collected.

The Electricity elicited in the animal tissues has yet another agency,—and one on which the very *existence* of those tissues depends, for without it, they would pass into a state of putridity and of rapid decomposition. This agency is equivalent to the *vis inertia* of the school-men : it is the power of resistance, in the antiseptic sense ; and it is not only essential to the duration of the organic structures under common circumstances, but pre-eminently so, to that of the Stomach, on which organ it bestows the faculty both of resisting, and of over-ruling by a superior force the ordinary chemical effects and attributes of the various compounds received as food.

This, it will be observed, is a most important agency ; so much so indeed, that Life must soon be lost without it. Under these circumstances, it became a matter of great moment to identify

this *vis inertia*, this *antiseptic quality* of the animal tissues, with the effects to be derived from Electricity: Under other views, the importance of this phenomenon has been duly felt, though its cause was unknown: Thus, without any knowledge of the Electrical Law on which the whole depends, Liebig has the following passage:—

“ One surface of the intestines, and the cells of the lungs, are constantly in contact with oxygen; and it is evident, that they must be as rapidly altered by the chemical action of the oxygen in the body, as out of it, were it not, that there exists in the organism itself a source of resistance, which completely neutralizes the action of the oxygen.” *Animal Chemistry*, p. 224.

Now the effect of the union of oxygen with the tissues in question, when enforced by artificial means, is, in the first instance, violent inflammation; and in the second, mortification, or the disorganization of the part with circumstances of putridity: With the same tissues, when already dead, the change into putridity occurs at once, with more or less rapidity of decomposition, according to the temperature, and the quantity of oxygen supplied.

Now under these conditions, it is plain, that the matter resolves itself into this:—that there

are certain circumstances under which the animal tissues imbibe oxygen, and others in which no such union can take place; and with the conviction, that the Laws of Electricity would solve the enigma, I instituted the following experiment:—having first of all taken the Electrical Law as a torch to guide me:—The Rule runs thus—No chemical union between different substances occurs, unless they are *in opposite states of electricity*—the one *positive*, and the other *negative*. I therefore took a piece of animal membrane—which, under common circumstances, would in a few days have been changed into a mass of putridity—and strained it in contact with the external surface of a cylinder of zinc, having a lateral opening, or slit down one side, which cylinder of zinc was placed within a second of copper, so as to constitute a battery, the fluid being water. Under this arrangement, the oxygen of the water united with the zinc, but not with the animal membrane, because the latter, from its close proximity to the zinc, had become more *negative* than the oxygen, and even capable of repelling it,—and thus protected, the membrane was found to be as fresh after the interval of three months, as at the first moment of the trial.

This experiment shows, that the principle

which constitutes the *vis inertia*, or resisting force, or, in other words, the antiseptic quality of the animal tissues, is a surplus of one of the Electricities; the *positive* or *negative* form having the preponderance, as circumstances may demand, and in accordance with the innate and superior vitality on which the Electro-Balance of the System depends.

In the living animal, when the *negative* character is essential, as in the case of the intestines, the Electro-Negative Force is given to the internal membrane of the canal by the alkaline character of the fæcal contents acting on the secretion with which it is lubricated.

This commanding Law of Electricity is of the most extensive influence in the process of Digestion; and a knowledge of its existence, and its power, is in this sense so indispensable, that the want of it has betrayed men of distinguished talent into singular misconceptions; and this has even been the case with Liebig, when speaking of the absorption of the gases.

He writes as follows: "Finally, if we consider the fatal accidents which so frequently occur in wine countries from the drinking of what is called "feather-white wine," we can no longer doubt that gases of every kind, whether soluble or insoluble in water, possess the property of permeating the

animal tissues as water penetrates unsized paper. This poisonous wine is wine still in a state of fermentation, which is increased by the heat of the stomach. The carbonic acid gas which is disengaged penetrates through the parietes of the stomach, through the diaphragm, and through all the intervening membranes into the air-cells of the lungs, out of which it displaces the atmospheric air. The patient dies with all the symptoms of asphyxia, caused by an irrespirable gas; and the surest proof of the presence of the carbonic acid in the lungs, is the fact, that the inhalation of ammonia (which combines with it) is recognized as the best antidote against this kind of poisoning." . . . "The presence of membranes offers not the slightest obstacle to their passing directly into the cavity of the chest." *Animal Chemistry*, p. 114.

Now, all this is true to a certain extent; persons have doubtless died in Germany from the suffocation occasioned by the carbonic acid gas evolved from new wine:—and I have myself seen the same sort of suffocation ensue from an extrication of carbonic acid gas in the stomach, when the System had suffered extreme attenuation, and vitality was reduced to the lowest ebb. And again, it is a common occurrence for cattle to die in the same way after having accidentally

broken into a piece of new clover, and over-gorged themselves with green food : but in all these instances, there is no such infiltration of carbonic acid gas into the air-cells of the lungs, as our author has imagined, but death ensues from a directly opposite cause. Not from a distention of the lungs, by that, or by any other gas ; but simply, because they are deprived of the power of expansion. In such fatal instances, the stomach becomes so enormously distended, that the action of the diaphragm is impeded, and at last altogether stopped, and respiration ceases.

The explanation of the use of ammonia is advanced on equally mistaken grounds. Professor Liebig assumes, that the *surest proof* of the presence of carbonic acid in the Lungs, "is the fact, that the *inhalation* of ammonia (which combines with it) is recognized as the best antidote against this kind of poisoning." Now we shall find, that this supposition is practically impossible, for by the union of the ammoniacal and carbonic acid gases, the *solid salt* Carbonate of Ammonia is immediately formed, and what would occur from this sudden deposition of *volatile salts* in the air-cells of the lungs, but the most intolerable and fatal irritation ? The *smelling* of ammonia is only useful in such cases, as it

stimulates the nerves, and so arouses the vital power of the system.

These remarks are as yet but counter-assertions, if we except the last;—but, the whole question resolves itself into this:—have the gases the power of permeating the coats of the Œsophagus, Stomach, and Intestines, or have they not?—We answer, that they have not this power during life; but that after death “the passage is as free as that of water through unsized paper.” The same facts occur with fluids, as John Bell states in his “*Anatomy*,” vol. ii. p. 306.

“It is proved, that in the *living body* there is no exudation; but no sooner is the animal dead, than the fluids exude from the vessels, the secretions pass through the coats of those receptacles which formerly contained them, and parts partake of the colour of that which is contiguous. From this fact we are led to think that there is a property in the living fibre which *repels* the fluids.”

It is interesting to observe how nearly Bell had arrived at the knowledge of this Electro-Principle, which Liebig had not even suspected, although it forms part, nay, the very soul of the “*vital force*,” created by the transformation of substance in the *combustion* arising from Respi-

ration, the subject on which his genius and researches have thrown such a resistless flood of light.

But to the question ;—if the living tissues have under the natural arrangements, the power of resisting the passage of certain gases and fluids, in what does that power consist?—We answer in the Law of Electrical Repulsion—any two substances when charged with the *same* Electricity, having the faculty of *repelling each other*, that repulsive power being subject to inversion where needful, as in the case of the secondary circulation of the capillaries.

Thus, in the instance before us—The Stomach being itself in a state of Positive Electricity—and the carbonic acid gas being *positive* also, they repel each other, and although the pressure with the increasing distention becomes very great, yet the mutual repulsive force remains superior to its influence, and no infiltration through the coats of the stomach can occur.

But again, how is this repulsive power lost by the stomach in death?—We answer, that as the Positive Electricity proper to the stomach is the result of the living functions, of the combustion and transformation of the animal tissues into carbonic acid gas, it ceases with the loss of Respiration, and the coats of the stomach be-

coming *negative*, the *positive* gas is readily imbibed, and passes through them without impediment:—indeed, the same circumstance happens to the Vascular System, the carbonic acid gas of the whole mass of the blood frequently escaping through the coats of the vessels.

CHAPTER IX.

PHYSIOLOGICAL IMPORTANCE OF ELECTRO-REPULSION.—THE
MODUS OPERANDI BY WHICH ARSENIC AND OTHER MINE-
RAL POISONS EITHER KILL OR CURE.—SALUTARY EFFECTS
OF IRON DEPENDANT ON ITS ELECTRO-POSITIVE STATE.—
DISTINCTION BETWEEN THE POISON OF SERPENTS AND
ANIMAL VIRUS.—THE CHARACTER OF FOOD DEPENDANT
ON ITS POSITIVE ELECTRICITY.—ELECTRO-ORIGIN OF
SCURVY.—ELECTRO-FORCES EFFECTING THE PERISTALTIC
ACTION OF THE BOWELS.—THE CHYLOPOETIC SYSTEM.—
GALVANISM EFFICIENT IN CHRONIC CONSTIPATION.

AS I have before said, the Law of Electro-Repulsion, in its physiological sense, is a great and commanding Principle. It raises the veil which has shrouded for ages the vital functions of Digestion, and places the master-key in our grasp, with which we may unlock the most difficult passages of physical phenomena and medical treatment, with regard to that function and to its organization. Nay, it does more, it lays open before us some of the most hidden of those sympathetic effects in the general System which arise through the medium of the stomach; and which have often the happiest influence when artificially induced by medicine.

Let us take an example :—say Arsenic.—Like many of the other poisons, it has proved an effective remedy. In severe cases of intermittent fever, it has cured, when all other means have failed, and it has done the same in cutaneous diseases. But while these facts have been generally known, no explanation of the *modus operandi* of the mineral in effecting them has been supplied ; all, in this sense, has been mystery, for the vague assertion, “ that the effects result from electricity,” leaves the enigma as dark as ever.

Now if we apply the Principle in question, we shall find how Arsenic *both kills and cures*, by the same agency, that agency only differing in degree. In the first instance, then,—how does Arsenic kill ?—We answer, by its intense Negative Electricity. Thus no sooner is Arsenic swallowed, and so brought into contact with the *living* stomach, than each particle is immediately so attracted by the Positive Electricity of that organ, that it forms a chemical compound with the part on which it lies, which immediately becomes an inert and dead substance ; and which, if the patient recovers, sloughs off. But in fatal cases, many such spots are produced, and large patches of surface are affected : and then the most violent Electrical phenomena occur within the stomach. The

Positive Electricity of that organ being, according to the Law of Electro-Attraction, concentrated upon itself, by the proximity of the *negative*, assumes an intensity of action incompatible with the life of the part. The most violent and corrosive inflammation ensues, attended by great heat, as the opposed electricities coalesce. Agonizing pains arise, the system becomes exhausted, and death at last relieves the victim; but often not before the stomach has become disorganized into a mere mass of ulceration, and its very coats in part detached.

But we have said that Arsenic *cures* on the same Principle on which it kills!—It is even so;—for it cures by giving a greater degree of intensity to the Vital Electricity:—but with this essential distinction, that in this instance, the intensity is not incompatible with health; and is distributed over, and gives augmented energy to the Vascular, and *tone* to the Nervous System. These salutary results depend upon the subdued form of arrangement in which the Arsenic is submitted to the action of the stomach. This subdued influence is obtained by subdivision, and this subdivision is carried to an infinite extent; the separate atoms, being kept at some distance from each other. This object is effected in the *Solutions*; the only form used for medical

purposes, and in which the wine, or spirit furnishes the first intercepting medium. The subdivision gained by *Solution* is again rendered still greater by the addition of water, or of other fluids forming a *Mixture* when it is prescribed. By these precautions, the intensity of its *negative* character, by being diluted, acts on a larger space, with power, infinitely subdued, but still sufficient to attract the Positive Electricity of that organ towards itself; to support this action, the stomach absorbs more Electro-Positive Force from the System at large, and the consequence is, a more than usual Electro-Accumulation in that organ, with a slight evolvment of heat,—and the lungs partaking in the excitement of the stomach through the medium of the *pneumo-gastric nerves*, the Respiration is accelerated. After a little time, the subdivided atoms of Arsenic which have caused this excitement, enter into combination with the acid secretions of the stomach, and also in part with the food, so that their Electro-Negative character is neutralized; and then, the attraction ceasing, the accumulated Electro-Positive Force passes to the Spleen, and is thence distributed over the entire System, carrying with it a degree of re-action, which augments the flow of the blood in the capillaries, and thus counter-acts the intermittent depres-

sion of the circulation in ague, or relieves the vascular debility, in which the inflammatory affections of the skin so often have their origin. At the same time, a small proportion of the arsenic is carried into the circulation, and is immediately thrown off with the excretions, to which it imparts a more than usually *negative* character, and thus adds to the rapidity of their extrication from the body.

The Nitrate of Silver, on the same principle, owes its effects on the animal economy to the intensity of its Negative Electricity;—it is thus that it corrodes, when used externally as a caustic; and when taken internally as a remedy, it can only be in minute quantities, and on subdivision; it is also to be remembered, that its chemical properties, as shown by Liebig, are often immediately changed on its admission to the stomach, through its decomposition by the chlorine of the secretions.

Copper, and a long list of the poisonous Metallic Salts, Acids, and other compounds, which all owe both their deleterious influence, and their medicinal agency, to the *negative* character of their Electricity, might be added, were not such details foreign to our purpose.

The above is an outline of the *modus operandi* of these deadly poisons when converted by Me-

dical Science into remedies ; but after all, useful as they have been, some peculiar states of the constitution render their action more or less uncertain ; and it is very satisfactory to state, that their use may be entirely superseded, by a judicious employment of the Galvanic Agency, while the results so obtained are even more commanding ; and that the *re-action and debility* following the use of all the chemical compounds of Electro-Negative character, is then altogether avoided.

On the other hand, the friendly influence of Iron in many of the forms usually employed, is evidently to be ascribed, in the first instance, to the effects of its *positive* electricity. This Electro-Positive state, as proper to the blood, and to the stomach, and as identified with the energetic and healthy condition of the general system, has been so often before us under some of its salutary attributes, that it becomes the more interesting to find that it can ever be a source of mischief ; and yet, there are strong reasons for believing that, in a highly concentrated form, it gives to the animal poison of the serpent its deadly character.

A distinction is to be made here, between the poison of the Serpent and that of the Scorpion, which are vital secretions, and the *animal virus*

furnished by ulceration and decomposition, as in the plague, small-pox, and other contagious diseases, in which the poison so obtained is an excretion already in a dead and highly Electro-Negative state, and the same is the case in Hydrophobia.

As we have said, the poison of the Serpent is *positive*; and it may therefore be taken into the stomach with impunity, and is there apparently immediately decomposed without any injurious result; indeed, it is amusing to reflect, that the chemical analysis gives the same composition to Gum Arabic as to the venom of the Viper! But how great is the difference—for when the latter is brought in contact with the blood, the most fatal changes rapidly occur. The wound is generally in the hand or foot, and the capillary circulation of the entire limb, is often in a short time so wonderfully accelerated, that the part swells to twice its natural size; heat and inflammation soon occur; and with such violence, as to lead to the local decomposition of the animal fluids, as if the part were blasted at once with the last stage of a putrid fever! But the injury and its consequences, are not confined to the limb, they extend progressively over the entire system; and if the victim lives long enough, the whole body is in the same condition. The use

of the *carbonate of ammonia*, in the relief of slight cases of such poisoning, is in unison with these views, as this remedy causes perspiration, and, from its subtle and Electro-negative character, may, when carried into the System, serve very far to neutralize the poison. The action of oil as sometimes used in such cases is more obscure; and I am inclined to think, that its good effects depend on the friction used in its application, which, by blending it with the poison, renders it efficient, as a *non-conductor*, in depriving it of power.

But to return to the influence of the Electrical Law in question on Digestion. A moment's reflection will show us, that its application in respect to the choice and action of different kinds of food, must be equally practical and certain. Thus we perceive at once, that food, whether in a solid or in a fluid form, is more congenial with a weak and delicate state of the stomach, when supplied warm, than if taken cold, and that, evidently, because in the former instance it is already in a *super-Electrical* condition, and does not demand from the stomach so great an expenditure of Vital Electricity, or in other words, of Digestive Power. The above remark, it must be remembered, is only applicable to articles not essentially *negative*, for

these, however warm when taken, can only be digested by an *extra* Electro-Positive Force subtracted from the System at large, and directed on the Stomach. Now, this *extra digestive force* can alone be maintained at the expense of the general health, and if long continued, great debility, both vascular and muscular, is the inevitable result. The due Electro-Positive Character of the Blood, and of the tissues, is so lowered, that the *negative* excretions accumulate in the superficial glands ;—swellings of the legs, boils, and ulceration arise, the teeth are loosened from a shrinking of the gums ; and the Electro-Antiseptic influence of the stomach is so lost, that the food remains half digested, and half putrescent, tainting the breath with fetid exhalations :—Such are the symptoms of SCURVY ;—and the essentially *negative* food alluded to, is any salted animal substance, which, if taken long enough, will not fail to produce this horrible disease, whether used on Ship-board, or as *Prison* diet. We may proceed to observe, that many articles of food, which become *positive* when heated, are more or less in a weak state of *negative* Electricity when cold. It is thus, that in popular language we say, that this thing or the other, is “too heavy for the stomach :”—or, that it lies there, “like a lump of lead !” Now, the

effect is so real in this case, that the expression is hardly metaphorical ; and if the Reader doubt, let him test it by experiment. Nothing can be more easy—my good friend, you have only to take—say for supper, two pounds of cold potatoes, or of turnips without salt or vinegar, and you will have a mass of trash not sufficiently *negative* to excite the Counter-Electricity of the stomach, either to the extent of producing sudden heat, or inflammation ; but quite enough so, to bring the stomach into close contact with its contents by the law of Electro-Attraction, and there it must lie for hours,—cold, inert, and heavy, until at last, the chlorine and Vital Heat have so far changed its character, as to have induced fluidity and a low degree of *positive* Electricity, which renders it capable of being transmitted to undergo the second stage of digestion in the *duodenum*.

But this uncongenial unsavoury mess, simple as it may seem, may yet serve to instruct us in the rationale of one of the animal functions which has not hitherto been accounted for. I allude to the passage of the chyme or half digested food from the stomach to the *duodenum* and lower intestines. A superficial glance might lead to the conclusion, that this passage was merely a descent arising from gravity ; but so far

from this being the case, the same motion occurs when we lie in an horizontal position; nor is it in any way impeded if the abdomen is placed on a higher level than the shoulders;—nay, were it possible for a Tumbler to walk about on his hands, with his heels in the air for half a day together, this function would still proceed.

It is evident, then, that the series of *progressive motions* conveying the contents of the stomach towards, and in the course of the intestines is not the result of gravity:—how then is it produced?—We answer, by Electrical Attraction; its direction being the result of the impulsive agency which carries fluids in the Galvanic Circuit from the *positive* towards the *negative* pole; and that these effects are realized in the instance before us, by the relative Electricity of the stomach, and of the intestinal canal, the order of the contractions following the direction of the Electro-Current. If this view is correct, it is evident that, if the Electro-Poles were reversed, the contents of the bowels would be ejected upwards; and such is actually the fact in what is termed the *Iliac Passion*, in which a highly inflamed state of the small intestines, by overloading them with arterial blood, has rendered them intensely Electro-Positive; while the debilitated stomach is comparatively *negative*. And

if this corroboration were not deemed conclusive, we have a farther proof in the fact, that no sooner does gangrene occur, which throws the bowels into an Electro-Negative condition, than the vomiting of fæcal matter immediately ceases. Without being aware of its cause, Sir Charles Bell has the following passage on the contractile action in question, in his "*Anatomy*," vol. iii. p. 288 :—

"Nay, from experiments it appears, that a permanent irritation will cause an accelerated motion in both directions; that from the point stimulated there will proceed downwards the regular series of contractions and dilations, while the motion is sent upwards and retrograde from the same point of the intestine towards the stomach. And this observation the exhibition of medicine and the diseases of the intestines confirm."

We have in this phenomenon, a most instructive example of the Electrical Agency in question. The permanent irritation of a part of the intestine is attended with a preternatural Electro-Positive-Force in the muscular coat, so that the intestine on either side becomes comparatively *negative*, and the attraction is therefore on both sides equal.

Let it not be supposed, that the contractile

motions of the stomach, and the peristaltic action of the bowels, have been forgotten in reference to the question before us. They have not been explained in the first instance, because the fact is, that, although the great sources of motion, they do not govern its direction; and we find that they are equally potent, whether the contents submitted to their pressure, are propelled either in one way, or in the other: Still the progressive order of these muscular contractions is, in its natural state, of essential importance. First, we have the contractile influence of the Stomach: this was once supposed to be a regular alternate motion, which had a sort of mixing and shifting influence on the food, favourable to the process of digestion: such, however, is not the case, nor is it needed;—the Electro-Vital Chemistry has force sufficient for its object.

The rationale of the action is as follows. The stomach, when filled with food, does not at first contract, for if it did, the undigested contents would be prematurely ejected. No; the solvent process of digestion goes on, until, on the dissolution of the more solid compounds, an accumulation of Electricity occurs, which stimulates the nerves, and, exciting the fibres of the muscular coat into action, causes it to contract with a

steady pressure on the contents which, passing the pyloric orifice into the duodenum, there, by the addition of the bile, gain an Electro-Negative influence, and again excite compressive action, but under the peristaltic form; this is followed by other impulses in due succession; but slowly in the first and small intestines, where the chyle is principally absorbed; and as this takes place, the refuse, or fæcal matter, becomes more Electro-Negative, until it passes into the large intestines, and is in a great measure secured from return by the valve of the colon. But this peristaltic motion of the intestines, it should be observed, is effected in a manner opposite to the contractions of the stomach. That organ contracts by a surplus of its own, the Electro-Positive Force; but the fibres in the muscular coat of the intestines are excited in a different and secondary way: It is true, that they are thrown into action by the power of their own Positive Electricity; but this is condensed, and gains progressive activity in proportion to the degree of Electro-Negative intensity extended to the interior secreting intestinal coat, by the passage of the fæcal contents. This is the reason, why the sulphate of magnesia, and the other mineral salts, which are all highly Electro-Negative bodies, perform their office; and it is

thus, though in a secondary sense, that Castor and the other Oils act, being *non-conductors*; for in this character, they prevent the dissipation of the Negative Electricity from the mucous coat of the intestines, and thus as it accumulates, while the opposite Electricity is condensed, they give active *positive* force to the muscular coat.

The practical benefits to be derived from a knowledge of these phenomena in the application of medicine, and in the treatment of disease, would, if entered into, require a field far beyond our present limits; and yet, from its importance, I am tempted to advert to one particular in the use of salts;—it is, the impropriety of prescribing this remedy in any case in which we have reason to suspect that a *portion* of the intestinal canal is *already in a state of inflammation*; for the action of the salts would inevitably increase that inflammation during the period of their transit.

In a former part of this volume, it has been shown, that Galvanism has the power of exciting the action of the bowels by increasing the peristaltic motion;—its commanding influence on the secreting power of the liver, and on the discharge of the bile—which, be it remembered, acts by its Negative Electricity—has also been noticed; and it is doubtless, on the combined effects of

both these leading principles in the process of Digestion, that Galvanic treatment proves so safe, and so efficient a remedy in cases of *chronic constipation*; and that often when drugs have almost ceased to perform their office, and when much constitutional disturbance, irritation, and debility, have followed their reaction.

CHAPTER X.

ELECTRICAL FUNCTIONS OF THE SPLEEN.—OF EMETICS.—
OF THE ELECTRO-MOTIVE-DIGESTIVE FORCES.—ORGANIC
ELECTRO-ARRANGEMENTS FOR THE ABSORPTION OF CHYLE

HITHERTO, we have viewed the Digestive functions principally in connexion with their immediate organs; and the Spleen has been only mentioned as receiving the surplus Electricity of the stomach; but, I would now remark, that it appears highly probable, that the most important office of that organ is, to act as a *reservoir* for the extra Electricity of the Vascular System; and with a peculiar reference to its connexion with the Stomach, as, under certain emergencies, the supply of Electricity it might furnish to aid the solvent powers of its secretions would be of the first importance.

After death, when the blood in every other part of the body has been found coagulated, that of the Spleen has still been fluid, which indicates the previous passage of intense electricity, as the same fluidity, occurring in the

entire mass of blood, follows death from lightning, and may be considered a corroboration of our hypothesis, so far as it proves the especial Electrical Agency of the organ. It will be observed, too, that this view is in accordance with the ingenious and practical idea of Dr. Hodgkin, who thinks that the office of the Spleen is "to obviate any inconvenience that may arise from a sudden disturbance of the proportion between the capacity of the Vascular System and the fluids that circulate in it." The impunity with which this organ has been removed from quadrupeds, and the vascular turgescence in their extremities which has afterwards occurred—the enlargement of the Spleen in those who die of ague, and its cellular structure—are all facts which favour the opinion of its being designed to perform both the offices already mentioned.

It is an amusing circumstance, that although the Electrical Function of the Spleen has not been suspected for a moment, yet it has been practically employed for ages. I allude to its secondary influence in causing a revulsion of the blood on the use of Emetics.

However excited, the first effect of the influence on the stomach which induces vomiting is, to cause a muscular contraction of that organ, by which its Electro-Positive Force is concen-

trated until, the accumulation having exceeded the power of retention, it escapes, and the spasmodic restriction is simultaneously relaxed. On its escape, the extra Electro-Force passes to the Spleen, the Diaphragm, and certain abdominal muscles. The revulsion of the blood from the action of the Spleen is shown by the flush on the face, and by the sudden perspiration often induced; and the concurrent contraction of the diaphragm assists in throwing off the contents of the stomach.

It may be observed, that there are individuals who cannot be excited to vomit;—such is undoubtedly the fact; and the reason is, that the stomach in such instances is in a state of preternatural debility, from the absence of the due Electro-Force, and no concentration of the little left, can give the necessary power.

The influence of the Spleen when thus excited, is of the most commanding order, its extra charge of Electro-Force being transmitted to the Capillary System, so that a contracted state of its vessels from cold, debility, or febrile affection is overcome; the skin, if dry, is rendered moist; and heat, or any other undue accumulation of electricity, is carried off with the insensible evaporation. These are among the good effects obtained by Emetics; but the evils which may

occur from their use must not be forgotten. The first is the loss of Electro-Force from the System:—this always occurs more or less, and renders it injudicious for delicate persons to use Emetics often. The second is a loss of tone in the stomach:—this is always to be guarded against in strong individuals, by the use of Galvanism, and such medicines as favour the accumulation of an Electro-Positive Force in that organ.

In the *Absorption* of the Chyle, we have another particular which demands something more than the mere allusion already made; and yet, the whole Lymphatic System is so far a *terra incognita*, that the Electrical phenomena are almost all that we shall have to mention. In the main office of these vessels, there are two great distinctions: one large portion of their filamentous tubes has its origin in the secreting surface of the intestinal canal, where they absorb the white nutritious fluid termed chyle, after it has been elaborated by the digestive process:—the other portion of the Lymphatic System is distributed over the entire body, penetrating all the tissues, and pervading all the inner secreting surfaces and membranes, with an innumerable amount of minute vessels, and absorbing a fine transparent fluid termed lymph. Both these

branches, if so they may be called, unite by larger vessels into one common trunk, termed the *thoracic duct*, and, passing into the returning mass of the venous blood by the subclavian vein, deliver their contents to be immediately received by the heart, and thence transmitted to the lungs, where the respiratory change returns it to the System as a portion of the vitalizing arterial blood.

As connected with the veins, the contents of the Lymphatics receive the impulse of their motion towards the heart from atmospheric pressure; but as in their course they are at many points convoluted in the most intricate manner by glands, and everywhere subject to dilation from Electro-Accumulation, their coats are singularly strong; and so valvular in their construction, that a lymphatic vessel, when injected, has often the appearance of a chaplet of beads, from the successive pouches of its coats. The extensive apparatus of glands, with their attendant capillaries, nerves, arteries, and veins, devoted to the service of the Lymphatics, renders it evident, that the fluids conveyed by these vessels must be destined to undergo in their course, changes of the most important character to the constitution of the blood, and to the vitality of the System;—but what these changes

are, has not hitherto been discovered; and it need hardly be added, that the Electrical Agencies of the Lymphatic System have remained equally unknown.

A leading fact in this connexion, is the high Electro-Positive character of the Absorbents, which is an admirable ordination in the vital economy; for as the dead particles of animal matter, and of foreign bodies, which are occasionally removed by their agency, are in an Electro-Negative state, they are at once imbibed, and their electricity changed. But the same absorption occurs also with the poisons, which do not admit of the same change; and it is well, that in this instance, the slow motion of fluids in these vessels, and the local inflammation excited in their glands, lessen the direct shock upon the System, and afford time for the use of remedies.

Again, it is by their Electro-Positive power that the Lacteals, or Lymphatics of the bowels imbibe the chyle, which, as contained in the intestines, becomes *negative*, from the influence of the bile. The whole order of this process is one of the most curious in the animal economy; and it is truly interesting to find, that great physiologist, the late Sir Charles Bell, proving in detail, the Electrical Character of the pheno-

mena in question, although he had no idea that they originated in such a cause.

He writes as follows: "The most curious part of the structure of the intestines is the villous or inner coat; for by its influence is the chyle separated from the general mass of matter in the bowels, and carried into the system of vessels." He then goes on to state, that the villous coat has "a soft fleecy surface," and that it is of greater extent than the other coats, so as to be thrown into circular plaits, and thus very much "to increase the surface exposed to the aliment, so as to enlarge the absorbing surface." He next observes, that "the pile, or lanuginous surface from which this coat has its name, is to be seen only by a very narrow inspection, or with the magnifying glass. It is owing to innumerable small filaments which project from the surface, like hairs at first view, but of a flat or rounded figure, as the state of fulness and excitement, or depletion, shows them. They consist (as appears by the microscope) of an artery and vein, and lacteal, or absorbing vessels; and to these, we may surely add, the extremity of the nerve. They have a cellular structure; they are exquisitely sensible; and, when stimulated by the presence of fluids in the intestines, are erected, and absorb the chyle.

They are the extremities of the lacteal absorbing system, and their structure would seem to be subservient to the absorption by the mouth of the lacteal vessel."

Now in all, and each of these particulars, we have a complete *Electrical Apparatus* for the transmission of the chyle. The commanding influence of *points*, either for the absorption or the discharge of Electricity, is universally known; and the innumerable villi of the intestinal coat are nothing less, than so many points of such a character; while the organism for their erection, is at once the most beautiful and efficient that can be imagined, and at the same time equally simple. The contents of the intestine are *negative*, and the fuller it becomes, the greater is the Electro-Accumulation of this character present. In direct proportion to this influence, is the erective power of the villi, the blood contained in the vein and artery of each individual point being thus rendered more highly Electro-Positive, so as to give a vascular turgescence, and to stretch open the orifice of the point to imbibe the chyle, while the Electro-Negative attractive force of the surrounding fluid is at the same time drawing the villi forward. The next stage in this curious process is, if possible, still more striking as an adaptation of organic means for

realizing Electrical results; for no sooner are the villi filled with the chyle than they assume a *globular form*, which is the best for retaining the Electrical power, and consequently for causing that contraction which urges the chyle forward, and changes its electrical character. This process is thus described by Sir Charles Bell, *Anatomy*, vol. ii. p. 340: "When they are full of chyle, they take a globular form, and are called the Ampululæ. Their distention in consequence of a minute injection of the veins and arteries, is probably owing to a cellular structure (which they seem to have) into which the injection has extravasated. The most probable account of the structure of these ampululæ is, that this cellular structure is a provision for their distension and erection by the blood when excited by the presence of the chyle in the intestines; that this erection gives rigidity to the orifice of the lacteals; and that the first step of absorption is by capillary attraction, while the farther propulsion of the fluid in the extreme absorbents is by the contraction of their coats, excited by the presence of the fluid. Thus the absorption is not by an inorganized pore, but depending on excitement and action."

It would, doubtless, have given great pleasure to a mind so constituted as that of Sir Charles

Bell, had he been aware that the "absorption," the "attraction," "impulsion," "excitement," and "action," on which this great vital function depends, are so many distinct forms of that *electrical agency*, which is at once the origin of the chemical affinities, and the moving force in organic changes.

CHAPTER XI.

SYMPATHETIC INFLUENCE OF THE DIGESTIVE ORGANS ON THE GENERAL SYSTEM.—OF GOUT, RHEUMATISM, AND A CACHETIC STATE, AS ARISING FROM IRREGULARITIES OF THE ELECTRO-VITAL FORCE.—ELECTRICAL AGENCY OF MEDICINE.—IMPORTANCE OF ELECTRO-PHYSIOLOGY IN FORESHOWING THE ACTION OF DRUGS.—ORGANIZATION AND ELECTRICAL AGENCIES OF THE BRAIN AND NERVES.—ELECTRO-NERVOUS ACTION OF THE TORPEDO.—PRACTICAL ILLUSTRATIONS OF THE USE OF GALVANISM IN NERVOUS DISEASES COMPLICATED WITH INDIGESTION.

IN proceeding to the Sympathetic Influence of the Digestive Organs on the general System, the Reader will bear in mind that our object on the present occasion is, to point out the way to *leading principles*, rather than to follow up the minute details that they involve, and which, with such a theme, would be a task for Hercules.

Now, on the grounds of Electro-Physiology as already stated in these pages, I conclude that, in Gout, Rheumatism, and a Cachetic state of the System, we have in each instance, as the exciting cause, nothing more than *a loss of the due equilibrium* between the Electricity

of the Stomach and Respiratory Organs, and that of the Capillary System in the muscular tissues, and the Surface.

Thus, in Gout, we have a want of Electrical power in the Stomach, while the muscular tissues are in a highly Electro-Positive state; and when the fit comes on, this *extra electro-positive force* accumulates in the extremities, which are become too dry and non-conducting to give it due exit; and there it expands the capillaries with an intense inflammatory action,—changes and coagulates the secretions of the joints, and inflicts a torment past endurance; but, at the same time, leads not to suppuration, or to mortification, which results are, indeed, impossible, as the force in action is the great *antiseptic* agent of the System. If the attack falls upon the Stomach, the violence of the inflammatory symptoms affects by sympathy, the heart and lungs, through the pneumo-gastric nerves, and death is too often the result.

In Rheumatism, the leading principles of action are the same, but the distribution of the irregular force is different, and there is often a deficiency, rather than a surplus of the Electro-Positive power, which leaving the surface, accumulates in the muscular tissues, and in the periosteum, and always, more or less, affects the

circulation to the extent of slight fever, and sometimes induces serious oppression and disease of the heart.

In a Cachetic state of the System, we have again an irregularity of distribution of the Electro-Force; but in this instance there is an injurious deficiency of both the electricities, and a great want of the due Electro-Positive accumulation in the stomach; so that with the loss of vital energy, the whole System sinks into feebleness and a premature decay.

In these diseases, the use of Galvanic Treatment in its various forms, sometimes alone, and sometimes in conjunction with other medical agents, is of the first importance;—and I have had practical evidence of its power, in checking the constitutional tendency towards the recurrence of attacks of Gout, and of Rheumatism—and of its influence in infusing fresh strength and energy in Cachetic Affections.

The Electro-Nervous Energy directed on the stomach, although more or less connected with the phenomena already mentioned, may yet demand our particular attention in reference to the agency of certain bodies taken as food, and as medicine; and also, in connection with the *points* or villi which occur in the secreting coat of the stomach, and around which, the minute

ramifications of the nervous filaments are accumulated. These *points*, as observed in the instance of those adapted for absorption in the intestines, form an *electrical apparatus*, and present, whenever they occur, the most effective means either for electrical evolvement or absorption; and it is to be remarked too, that when the nature of the food taken by an animal is of such a character as to require a great electrical force for its reduction, as in the instance of the fresh grass and herbage taken by sheep, the villi in question are, in proportion, both large and numerous.

The immediate Electro-Nervous influence on the stomach is clearly shown in instances of mental excitement, as when vomiting occurs from fear,—when there is a sudden evolvement of the Electro-Positive energy on the muscular coat of the stomach, and the sympathizing parts, as the diaphragm, &c., produce the necessary convulsive concussion.

The Electrical influence of agents affecting its nerves, when taken into the stomach, is of a very important character. Thus when the digestive functions are in an inert and feeble state, so that the ordinary articles of food, which have little electrical character of either the one sort, or of the other, afford no due excitement, the

use of some condiment more sensibly electrical, as an anchovy, or a pickle for instance, or sometimes, even an extra pinch of salt, will rouse the stomach into action, by exciting its nerves, and thus producing a surplus of Electricity. The effect of certain drugs is still more strongly marked. Thus the sulphate of quinine, which is an active *negative electric*, containing nitrogen in a concentrated form, is capable of producing the most marked effects on the entire System immediately after its contact with the stomach.

In thus alluding to the Electrical Agency of Medicine, as before observed, we are stating nothing new. From the moment when Sir Humphrey Davy established the *identity* of the chemical affinities, with the Electro-laws of motion and attraction, it was equally certain, that the influence of all material agents, when received into the body, was electrical also ;—but this, like other leading truths, had to work its way slowly ; and too much honour, in this sense, cannot be paid to Dr. Samuel Dickson, whose penetrating genius has done so much to clear away the dust and cobwebs of the schools, for the clear and decisive tone in which he has brought the subject forward.

“It is entirely owing to the *electrical power*,

by which they influence the atomic motion of certain parts of the body, through the medium of the brain and nerves, that all agents act—all agents, with the exception of such as mechanically, or chemically alter the tissue of the locality to which they are applied.—By this power prussic acid relieves spasm—opium soothes—antimony vomits, and rhubarb purges. The primitive agency of all four, then, is *one* and the *same*, namely, the power of “wakening or controlling motion, of altering temperature; their ultimate and apparently unlike results, only differing in the apparent dissimilarity of the functions of the organs which they respectively influence.”—*Page 254*. Again at *Page 255*, he says—“But you may here fairly ask, why does opium set one man to sleep, and keep another wakeful? I answer, why does amber, when rubbed, attract a particular substance, and afterwards repel it? Is it not that it becomes thereby electrically changed? what eye can detect that change? It is because the state of the brain of these individuals is electrically opposite, that you have opposite results from opium. Opium, like amber, must therefore produce inverse motions—in one case *attraction*, in another *repulsion*; and that is the reason why mercury cures iritis in one individual, and causes it in

another; why prussic acid can excite and relieve cramp; why terror has cured epilepsy, and frightened others into epileptic fits. The attraction and repulsion of the atoms of organs, then, not only account for organic increase, decrease, and decomposition, but for every variety of change which the body assumes, whether in health or disease. It is by attraction, that the fluid matter of a secretion becomes consistent and organized, again to be thrown off by the same organ, in the fluid form of *secretion* by repulsion."

Again, when speaking of Prussic Acid, and its good effects on *incipient* Consumption, as proved in the practice of Magendie, he says, "People, who have accidentally taken an overdose, will tell you that they felt as if they had had an *electric shock*. Whatever produces a sudden impression upon the whole frame, causes such a shock. Whatever acts upon it more slowly does the same in *effect*, as galvanism or electricity slowly and gradually applied. How otherwise can you influence the body in disease

" With drugs or minerals
That *waken motion* !"

SHAKESPEARE.

The action of such substances, I do not require to tell you, is anything but *mechanical*. What

then can it be but *electrical* or *galvanic*? To call it chemical, or magnetic, is only an admission of my position, for these have been proved by Mr. Faraday to be mere modifications of the same great principle. We can now understand how galvanism and electricity may be directly and advantageously employed in every disease that has obtained a name, ague and consumption among the number."

From these extracts it is evident, that no man is better acquainted with the direct electrical agency of medicine, than Dr. Dickson, but in saying that, it is by this power that "*drugs influence the atomic action of certain parts of the body, through the medium of the brain and nerves,*"—it is evident that he has given us only one half of the subject. No drug can be prescribed with that *previous knowledge* of its effects, which is requisite to render Medicine a *Science*, unless the Electrical Laws and condition of the Human Body have been *previously* ascertained; without this needful foreknowledge, all must be mere *experiment*; and with his usual candour, Dr. Dickson has most emphatically said so. Of this remark twenty instances might be given,—at *Page 266* he observes, that—"The *electrical* state of the body, *which cannot be known* but by an experi-

ence of their effects upon it—determines, whether squill or digitalis prove aggravant or remedial.”

These statements, and this *supposed* impossibility of obtaining even the leading principles which can alone give the practice of medicine the safety of certainty in its progressive steps, may show us the vast importance of Electro-Physiology, which at once affords the necessary data. But again, it is a mistake to imagine, that medicines act in the first instance on the brain and nerves—their primary action is on the *electricity* of the Secreting Surfaces with which they come in contact. The action on the nerves is secondary:—the third action, is dependant on the origin of the nerves, and is either on the spinal chord, the medulla oblongata, or on the brain. Fourthly, there is the communicating influence on the Sensorium; and fifthly, there is the *reflex action* from the centres of the nervous origins, by which an operating force is thrown out upon the whole, or on part of the Vascular System, or on the surfaces, or secreting organs; and be it remembered, that, together with this Electro-Nervous Action, there is that of the Blood, as before explained.

We may illustrate this by a familiar example of every-day occurrence. When an extra quantity

of vinegar has been taken by a person in health, there is frequently a sense of heat in the stomach, occasioned by the instant and local union of the two electricities:—secondly, there is a flush in the cheeks, and often a sudden perspiration on the forehead, from the increased local arterial action, an extra charge of electricity having been expended on the vascular system of the face from the portio dura, a nerve branching immediately from the pneumo-gastric nerves, which are themselves charged by the extra electro-positive force accumulating in the coats of the stomach, from the presence of the electro-negative vinegar.

Again, if we seek an example of this nature from the action of a medical agent, we shall find that the principles of Electro-Physiology will at the same time indicate the propriety of its employment, and explain the *modus operandi* of its influence. We will take one of the most universally known and efficient articles of the Pharmacopœia, the one before alluded to, the *Sulphate of Quinine*. This drug is one of the Electro-Negative agents which act by augmenting the Electro-Positive accumulation of the stomach, and that with a sustained energy which, passing to the Spleen, is diffused to the blood, and gives an increased constrictile power

to the whole arterial system. On this principle, we can at once understand the influence exerted by the *Sulphate of Quinine* in Ague; a disease in which there is a want of the due sustaining arterial energy, with an intermittent accumulation in the Spleen:—and again, in the more ordinary forms of debility, in which the exciting influence of the Electro-Positive Force is also wanting; and the effects on *languid ulceration* are of the same character. In all these instances, therefore, the knowledge of Electro-Physiology presents us with solid and certain grounds for the exhibition of the *Sulphate of Quinine*.

On the other hand, when there is a demonstration of the Electro-Positive condition on the surfaces, it is equally evident that the use of the *Sulphate of Quinine* is interdicted. It will cause cough, shortness of breath, dry heat of skin, headache, restlessness, loss of sleep, with, in some instances, occasional fits of reaction, having all the character of Ague:—and in other cases, a loss of digestive power, with contraction throughout the whole of the intestinal canal.

On these leading Principles, the effects of the other medical agents are equally evident; but we must pass on to a consideration of the immediate condition of the nerves under Electrical Excitement, and the agency which follows.

We have said that this condition is one of *tension*, and that the action is by *vibration*, and that there is reason to conclude, that the form of electricity is that of *intensity*.

Now, under these circumstances, it is curious to find that the organization of the brain, and of the nerves, is precisely such as the ordinary Laws of Electricity would have required. Thus the cerebrum is constituted by a viscid, gelatinous, semifluid substance filled with translucent globules containing an albuminous fluid,—these globules being arranged in regular succession, so as to form rows, and these rows being again collected into fasciculi. There is also a peculiar fatty matter, with traces of phosphorus, and of the chloride of sodium. The power of round bodies in retaining a charge of electricity, has been already noticed; and in the formation described, we have a complete electro-battery of this description. Under ordinary circumstances, each of the globules would retain its proper electricity in a passive state; but on the addition of fresh electricity from the spinal cord, and in other instances from the blood, an accumulation would arise in the globules—these would first repel each other, and, by the mechanical pressure so induced, cause an augmentation of their relative electricity; and if these

reciprocal actions are carried to a certain point, a simultaneous discharge from the whole of the globules, or from one of their fasciculies, according to circumstances, will occur.

The same phenomena, to a certain extent, take place in the cerebellum; in the medulla oblongata; and in the spinal cord,—the nerves connecting these with the various parts and organs of the body being so many conductors of the Electro-Force, which, under different circumstances, is propagated either to, or from the brain, or the immediate origin of the nerves,—and in the latter case, constitutes the *reflex action* of the nervous system, the existence of which is so ably proved by Dr. Marshall Hall.

We have said that the Electrical action in the nerves is one of *vibration*, but of course with a capacity for the augmentation of quantity, and of transfer, or, in other words, the passage of electrical currents. Thus, under ordinary circumstances, the nerve, which has a substance similar to that of the brain confined in a cellular vascular sheath, is already in the condition of Electro-Tension; and this being the case, any Electrical impulse at either extremity would at once affect the intermediate line, and be thrown with increased power on the opposite end; exactly as when one end of a sonorous body, say

a tuning-fork, is struck, the vibratory action increases towards, and the sound is propagated at, the other end. This ordinary Electro-Tension of a nerve is doubtless derived from the arterial blood; for we find that, if the blood be withdrawn from a limb, its power of sensation, and even its capacity for Galvanic excitement, as proved by Fowler, is in proportion lost; and that a deficient supply of arterial blood to the brain leads to inanity, and to a loss both of mental, sentient, and muscular power.

Another, and most interesting particular in the Nervous System, is the beautiful arrangement in the organization of the nerves at those extremities, which are destined to receive the various impressions of the senses. Here, again, we have a recurrence of villi, or *points*, with different modifications. Those of the cutis vera, for instance, which give us the sensations of touch and temperature, which are both Electrical, the first arising from the extrication of Electricity on pressure. The villi of the tongue are well described by Sir Charles Bell, who little thought that he was bearing conclusive evidence to the electrical nature of a vital function.

“The papillæ, which are the organs of taste, are to be seen on the point and edge of the

tongue, and consist of a pretty large vascular soft *point* which projects from an opaque and white sheath. If we take a pencil and a little vinegar, and touch, or even rub it strongly on the surface of the tongue, where those papillæ are not, the sensation only of a cold liquid is felt; but when you touch one of these papillæ with the point of the brush, and at the same time apply a magnifying glass, it is seen to stand erect, and rise conspicuously from its sheath, and the acid taste is felt to pass, as it were, backward to the root of the tongue."

The instant erection of the papillæ, by the accumulation of its Positive Electricity on the application of the *negative* excitement of the vinegar is so clearly electrical, as hardly to need comment.

A question may here arise, and a startling one too:—As Vision is one of the senses—is it also the result of Electricity?

The knowledge hitherto obtained of Electricity, is not sufficient to enable us to give this question a decided answer; but there is a great probability, that the reply when it can be given, will be in the affirmative; and that it will be found that sight arises from the galvanic influence of light on the retina.—The reasons for holding this opinion are,—first, that the red rays of light

induce heat, which proves the presence of both the electricities,—secondly, that the violet rays have the power of conferring magnetic influence;—needles having been so magnetized,—and thirdly, that light shows chemical agency in the deoxidation of many compounds.

Having thus shown the commanding power of Electricity over the higher functions of the human frame, it may not be improper to remind the Reader, that we have already said, and indeed proved, that Electricity is second to the Vital Principle;—It is not life!—but in the hand of the Omnipotent, it is the great minister of his life-maintaining energy.

A very beautiful explanation of the influence of the nerves is shown in the Electrical functions of the Torpedo. Now the fish wills the shock before he gives it, and when he wishes to oblige us with this stunning evidence of his attention, let us inquire how he is to bring his battery into play, for his electrical organ is a *battery*, to all intents and purposes, and one consisting of no less than 150,000 cells: These cells are arranged in columns; and in each instance constituted by alternate structures of different conducting powers, and so placed that the heterogeneous parts are separated by humid layers of a less perfect conducting power—the

consequence is an accumulation in each of the cells. Now, around these cells are placed a large number of nerves, which John Hunter in his able description of its anatomy very sagaciously concluded to have some connection with the electrical power of the fish. This is undoubtedly the fact, for at the instant of giving the shock the eyes of the animal are evidently drawn inwards with a sudden motion, perhaps accompanied by a shrinking or self compression of its brain, and such I believe to be the case, for such a compression would occasion an over-charge of electricity throughout the nervous tissues of the Fish, and this impulse on the *loaded battery* would cause the discharge.—The loss of power which follows repeated shocks, shows that the electricity is derived from the vital fluids, and that it requires time for its re-accumulation. In man there is compression too, more or less, on occasions of mental application from increased vascular action, and in moments of great excitement; this is very sensibly felt in a sudden rush of blood towards the head; and is often attended with indistinctness of sight from pressure on the optic nerve.

Having thus far explained the Electrical Functions of the Nerves, we may allude to the Galvanic Treatment of those complications of

diseased action which are comprehended under the term of Nervous Affections. As muscular motion depends on Electro-Nervous excitement, we may next treat of Paralysis, and conclude with a brief notice of the influence of the Nerves, and of Galvanism on Secretion, on Certain Diseases of the Bladder, and in some other particular instances.

There is no class of maladies in which more torture is inflicted on the sufferer than in those termed *Nervous*, and in which, while there is no change of structure, there is every sort and variety of pain, and every description of irregular action. In a multitude of such cases, medicine, after a long and careful trial, has been found worse than useless—for when the System is reduced by long continued illness, there is a want of the Vital Electricity which no course of drugs can ever supply.

In these instances, the judicious employment of Voltaic Electricity is invaluable, as it supplies the deficiency, and restores to the electrical sympathies, perverted by disease, a due direction. The following instance may explain these views; the patient was a young lady of eighteen:

When first consulted on this case, in the June of 1841, I was informed, that she had suffered from brain-fever in the July of the previous

year, and had since remained in a state of broken health, with more or less indigestion, and an irregular state of the circulation, with violent, and indeed, overpowering pains in the head. In addition to these symptoms, she had for *four weeks lost the power of swallowing anything more than fluids*;—her spirits were often distressingly low, and the pains occurred more or less daily, and were described as arising under the crown of the head, with a great sense of weight, and at either side of the neck, with an evident swelling of the vessels, this being greatest at the point where the external carotid branches off. The appearance was somewhat excited, weak, and febrile, with a very slight contraction at one corner of the mouth.

Under these circumstances, my first object was to induce a return of the usual constitutional flow of Electro-Nervous influence towards the extremities; that flow being indicated in ordinary instances by the sensible perspiration of the feet, and more slightly in that of the hands. An application was accordingly made, first, from the cervical vertebræ, and secondly, over the nervous plexus of the par vagum, and the sympathetic, to the extremities.

These applications were made carefully on both sides, and the much greater sensibility of

the left evinced the probability of pressure, on the opposite hemisphere of the brain. This unequal sensibility, however, passed away, and with it the contraction at the corner of the mouth, which has never since returned. In the meanwhile, the circulation became gradually equalized, and before the half hour which limited the application had expired, there was an increasing bloom on the cheek and a restored vivacity in the patient that augured well for the future. Nor were these hopes disappointed, for her friends on the next morning were delighted by her being able to take some prawns at breakfast.

On future occasions, the same plan of Galvanic Treatment was pursued, except that applications were also made both externally and internally to the affected part of the throat; and by these means, in a few days the power of swallowing was altogether regained. Small doses of the due medicines were also given, and after six applications, the patient's health was completely restored.—The state of the circulation was all that could be desired;—the indigestion was entirely corrected, and the pains in the neck and head were removed;—in a word, the patient was cured,—and the cure has been permanent.

This was one of the most rapid recoveries from a serious disease, which I have ever witnessed : and I have now before me a very handsome letter from this lady's father, in which he expresses his readiness at any time to bear personal testimony "*to the efficacy of Galvanism,*" and to the "*signal benefit*" his daughter had received from—what he is pleased to term, my "*judicious treatment of the very distressing complaint under which she was labouring.*"

Complications of Vascular and Nervous Disease are so common in *Female Constitutions*, and Galvanism is so effective a remedy, that there is some difficulty in the choice of examples. I will, however, describe one in which the symptoms were serious, but of another class. A young lady, with impeded circulation, had thrown up blood, undoubtedly from the throat, but sometimes in considerable quantities, for nine days;—she had a short, hard, and troublesome cough; there was too, both pain and oppression of the chest, and the feet were chilly. In this case the due vascular equilibrium and energy were restored within one hour after the first Galvanic application :—the cough and the spitting of blood had ceased on the next day, together with the coldness of the extremities,—

and in a very short period, the patient was altogether well.

The permanent restoration of an improved condition of the circulation, with a *warm and comfortable state of the feet*, has so generally followed the application of my plan of Galvanic Treatment in *Female Cases*, that, I feel it right to mention one still more signal instance, as it occurred to a lady in later life, who told me that her feet had previously been always cold, and that even when she was residing in the vicinity of Naples.

Nervous Diseases implicating Indigestion with general Debility, are not the exclusive property of female patients; I have frequently had to encounter these maladies in the other sex. A gentleman consulted me with irregular appetite; sudden feelings of exhaustion; a pain at the lower region of the spine, and what might be termed, a chronic *debility*. These symptoms were all removed in a little more than two months; the patient in the meanwhile obtaining an *additional weight*, of upwards of three pounds.

The increase of weight, which has been obtained in so many instances, under my plan of Galvanic Treatment, must undoubtedly arise from the coagulating influence afforded by the

form of *quantity* which I have used to a great extent, and which also operates most beneficially on respiration, and on the secretions.

In another instance, a gentleman went through a Galvanic Course with equally satisfactory results, who had suffered from debility and indigestion, accompanied with a shrunken state of the surface, and a peculiar dryness of the skin—and it must be added, some irritability of temper too. The last symptom was the first to give way; and after a short period, he left me with a ruddy cheek, and every other appearance of renovated health.

It may be proper for me to add, that in both the above instances, the patients had previously had the advantage of the first medical advice in the common sense of the term, but without success, and that simply, because the diseases from which they suffered were such as physic could not relieve.

CHAPTER XII.

THE GALVANIC TREATMENT OF PARALYSIS, WITH A PRACTICAL ILLUSTRATION.—THE CAUSES OF CONTAGION AND FEVER EXPLAINED BY ELECTRO-PHYSIOLOGY.—DIFFERENT APPEARANCES OF THE OPPOSITE ELECTRICITIES AS VIEWED IN VACUO.—INFLUENCE OF GALVANISM IN AUGMENTING THE SECRETIONS.—THE ELECTRO-MOTIVE FORCES OF MUSCULAR ACTION.—WANT OF CONTRACTILE POWER IN THE BLADDER, ETC. RELIEVED BY GALVANIC TREATMENT.—ELECTRO-DECOMPOSITION OF HUMAN CALCULI.

I AM now about to treat of another form of disease, in which Electricity has been supposed to possess far greater power, but where, in reality, its influence is infinitely less certain, and sometimes entirely fails—I allude to Paralysis.

It is now said that Electricity is unavailing in Paralysis, when *structural lesion* exists, or in other words, when there is any mechanical pressure on the nervous tissues at their centres, origin, or course. This is indeed true, when the obstruction is of a permanent character, and I fear we must consider pressure from bone, and generally from cartilage to be so—but when it

arises from a thickening of the membranes, owing to a turgescence of their vessels, as is sometimes the case, in the sheath of the spinal marrow, there are good grounds for expecting relief from absorption. The *moxa*, and other severe means of counter-irritation, have been used, and often successfully with this view—but Electricity has been considered as out of the question.

It has been one of the objects of my practice to render Electricity available for this object; and by a form of apparatus invented for the purpose, I am enabled to produce local excitement to any extent that may be deemed requisite, and with great advantage to the patient, who may thus escape the *continuous pain*, the blisters and wounds of the ordinary system.

In another point, I presume, that the treatment to which I allude, will be admitted to present new and important advantages in Paralysis; insomuch, as it has caused an increased growth of the affected muscles, a result which doubtless arises from the constitutional energy infused.

The many ordinary cases of Paralysis, *without structural lesion*, relieved by Electricity, as used at Guy's Hospital, may be considered as affording sufficient evidence of its influence over the disease, in that form, and I will therefore describe one of the compound cases which has occurred

in my own practice;—the one selected is the most arduous I have ever encountered.

In the November of last year I was consulted in the case of a gentleman of nearly twenty, who had for six years suffered from a lateral curvature of the spine, with hemiplegia of the left arm, permanent contraction of the thumb on the same side, and paralysis of both the lower limbs; that on the left side being the worst; but both were altogether useless, and wasted away to a fearful extent. For three years out of the six, the patient had been kept in an horizontal position, with the view of correcting the spinal curvature, but only with partial success, as the paralysis of the muscles from which the contraction arose had not been relieved. The general health too was much impaired:—the appetite was weak; and the digestive process slow and irregular;—The superficial circulation was in a languid state; and the extremities frequently suffused with clammy perspirations;—the leading professional authorities had pronounced the case hopeless; and galvanism, in the common way, had been used for three months without benefit.

I must confess, that I viewed this case with some intimidation; but still there was one particular, which encouraged me to hope that something might be done. It was, that the mental

faculties, originally good, were still unimpaired. I therefore undertook the case, but with a caution to the relatives, that it was one that only admitted of partial restoration.

The first Galvanic application was made with the view of inducing an equilibrium of the circulation ; and the increased arterial action which followed, gave the patient a new feeling of warmth and comfort. The next object was to test the power of muscular contraction under Electro-Excitement, and the result was satisfactory as it regarded the lower extremities ;—in a note written on the next day, the patient observes—“ I think that I am decidedly better for Thursday’s visit, having *a genial warmth in my limbs*, and I think that my right leg is more free in its action.”

After this, a varied and very careful plan of Galvanic treatment was pursued, embracing both constitutional objects in the improvement of the general health and the restoration of motion. In the first instance, the amendment was rapid, and in the second, a slow but visible advance was made. In the meanwhile, the patient was gradually habituated to a change of position, and was soon able to sit up for several hours in the day with advantage. As the contracted thumb of the left hand was crooked in

upon the palm so as to be useless, it was most desirable to restore its motion, but notwithstanding the energetic means employed, a considerable period elapsed before this object could be accomplished, and when at last gained, it was suddenly,—indeed, in a moment!—The restoration has been permanent.

A letter written to a third party, by a near relative of this young gentleman's, at about that period, conveys so good a sketch of his condition that I am inclined to quote it.—

“My son's case is one of paralysis with curvature of the spine, brought on six years ago by catching a violent cold; he has entirely lost the use of both legs, and one arm: until lately, he has been under Dr. Harrison's treatment without any good result, excepting as to the spinal curvature.

“At the recommendation of a friend, I was induced to apply to Mr. Humphreys, who commenced his course of Galvanism at the beginning of last November.

“When Mr. Humphreys first saw my son, he said it would be useless to expect, that he would ever be able to walk; but since his Galvanic treatment began, he has gained a great deal of benefit in strength, health, and motion, both in the limbs and hands, particularly in the thumb:

his health also is very much improved, and the size of his limbs is gradually increasing."

The growth alluded to was not limited to the limbs, as the patient had also gained a considerable increase of weight. Of the limbs he speaks as follows:

"DEAR SIR, January 18, 1841.

ACCORDING to your desire I took the measure of my left leg round the calf yesterday, which I enclose with that taken on the 2nd of November 1841, I was much surprised to observe the great increase which had taken place in so short a time since the commencement of your treatment, not above two months and a half, after having been more than six years without the slightest increase of size or benefit—during the whole of that period, I had consulted Sir Benjamin Brodie, Mr. Aston Key, and others—and I am rejoiced to see the great increase of strength in my thighs, which were before almost without power, both of which are to be attributed to your judicious treatment. I remain, &c."

As I had previously stated, it was impossible to restore the power of walking; but eventually the patient was enabled to use crutches with some advantage. I had reason to conclude

that the hemiplegia arose from pressure on the medulla oblongata; and that there was also a thickening of the sheath of the spinal cord, occasioned by the inflammation which had followed the cold that had produced the disease; and under this view, the spine and its muscles were stimulated, to produce absorption, and with success, as a far more upright carriage was obtained; this improvement of the spine may be best shown by the following statement from Mr. Ferguson, the *Surgical Instrument Maker*.

“SIR, 21 Giltspur Street, April 12, 1842.
THE alterations made in Mr. ———’s support for the Back in consequence of his having become more upright under your treatment have been very considerable. The *Arm Piece* on the right side has been raised as much as two inches, so that the *Arm Pieces* on both sides are now on *the same level*. I am, Sir, &c.

J. D. HUMPHREYS, Esq.
10 John Street, Pentonville.

This case occupied, altogether, a little more than five months; and certainly a much longer time would have been needed had it not been for the great advantage which the patient possessed in the command of every domestic means;

and in the judicious and zealous co-operation which my plan of treatment received from his relatives.

There are other forms of Paralysis, in which the secondary symptoms presented are weakness, and a constant coldness from the want of blood, and a languid circulation. In these cases, some of the combinations of oxygen are useful with galvanic treatment; and much advantage may be obtained, by placing the patient in an atmosphere artificially charged with positive electricity. We may here observe, that the general *electro-positive* state of the Atmosphere is one of the most important provisions in the Economy of Nature; and, with that profound design which is everywhere visible, it is provided for by the electrical law which renders the vapour arising from the solutions of the mineral salts *positive*; and as the waters of the Ocean are highly saline, it follows, that the *electro-positive force* is generally present in the atmosphere,—and the more sensibly this form of electricity appears, the greater is our sense of support and vivacity;—but on the other hand, when the air becomes *negative*, as is often the case before rain, a feeling of nervous depression, and in some individuals of a strange uneasy restlessness, is often produced.

The matter requires much greater investigation than I have hitherto been able to give it; but from several particulars, I am inclined to believe, that some forms of malignant disease have their origin in *electro-negative currents* arising from the earth. The curious fact which has been publicly noticed by an anonymous writer in the "Times,"—viz. that the *oil-porters* and other persons following trades which render *the skin greasy*, have uniformly *escaped* the contagion of the Plague, may be accounted for under this view of the opposite physiological influence of the *separate* Electricities. For as the oil would infinitely increase the *non-conducting quality* of the skin, the electro-positive force of the blood, on which the possession of health depends, would be in proportion retained.

The application of this fact involves consequences of the utmost moment, for the whole *question of contagion* hangs upon it! All the known causes of Plague, and of Fever, manifest a *surplus* of *Electro-Negative Force*. The fetid fumes of animal putridity, the evaporations of stagnant water, the exhalations of vegetable decay;—in a word, all the varied shapes in which Miasma scatters the seeds of death in the unseen Pestilence, are following in its train. The power of escaping from these evils lies in

the constitutional strength of the individual exposed to their action; and this strength is constituted by a *Surplus* of *Electro-Positive Force*; and if the *Negative* contaminating influence by which he is surrounded is still more powerful, he falls a victim to *Contagion*. A long exposure to a *negative* influence of the same nature, although less condensed, will yet be followed by the same result; for the *Positive Electricity* of the Blood will be slowly reduced by the discharge occurring from the insensible perspiration during the whole period; and when once its due *surplus* is lost, *Fever* is the inevitable consequence of the unnatural equilibrium which ensues.

A very curious fact in connexion with this subject, is the perfect impunity with which the Black Natives of Africa escape from the local diseases which are fatal to Europeans. The commonly known fact, that the black hue of the skin, by absorbing the light, and changing the radiant into sensible heat, and thus preventing that blistering of the cuticle from which the European suffers, is not a sufficient answer here, for the *White Man* dies from Miasma and fever quite as soon when housed and shaded from the sun, as if exposed. It is evident, then, that the *Black* escapes by an *extra Electro-Positive*

Power, which renders him superior to, and independent of, the deleterious *negative* atmosphere to which he is more or less exposed; and the question is, how this superior vital energy is furnished and retained? We answer, by the deposition of *carbonaceous matter* in the *rete mucosum*, which gives at once the dark hue to the complexion, and, by its great faculty of absorbing electricity, occasions the necessary accumulation. A more beautiful display of design, by the adaptation of means to a result, could hardly have been imagined, than is shown in this example.

In conclusion, I would remark, that there is every reason to believe, not only, that the practice of *Anointing the Skin*, but the precaution of living in, as far as possible, or at least of breathing frequently, an atmosphere artificially charged with *positive electricity*, would be an efficient defence from *miasma*—and that the latter expedient would often prove useful in the treatment of Fever.

Again, it should be stated, that all the evaporations from the acids are *positive*; and thus the use of *Vinegar* in sick chambers has, as it were, instinctively arisen. Another instance occurs in the use of *Sea-Water*. This fluid, from its saline properties, is an *electro-negative*

agent, and excites the counter electricity of the body, which accounts for its efficient action as a remedy in *Scrofula*, and in many other diseases attended with *Debility*. On the whole, this is a principle of practical importance, not only in the momentous instances we have named, but in our domestic economy; and if Electro-Physiology had been duly studied, the every-day folly now committed, of ordering a shower-bath without the addition of a little *salt*, or *acid* to the water, would never have been heard of; for every physician would have known, that twice the benefit would accrue from the saline or acid form, while the risk of subsequent cold, or debility, would be altogether avoided.

In having spoken of the *opposite* influence of the two electricities when acting immediately on the Nervous System, I have not as yet observed, that I am an adherent to the opinion, that the *antagonist electricities*, although always present in different proportions, are yet *distinct* in their nature,—so that the terms *positive* and *negative* have been used by me, not because I consider them appropriate, but simply because general use has rendered them the best understood. Of the visible illustrations of their *dissimilar character*, the following curious experiment of Faraday's appears to be one of the

most conclusive:—A glass globe filled with highly rarefied air (in the common sense a vacuum) was provided with brass rods sliding through close orifices in the sides. These rods being brought into contact, were charged with the opposite electricities—they were then drawn asunder:—“At the moment of separation a continuous glow came over the end of the *negative* rod, the *positive* termination remaining quite dark. As the distance was increased a purple stream or haze appeared on the end of the *positive* rod, and proceeded directly outwards towards the *negative* rod, elongating as the interval was enlarged, but never joining the negative glow, there being always a *dark space* between them. This space, of about the $\frac{1}{18}$ or $\frac{1}{22}$ of an inch, was apparently invariable in its extent and its position relative to the *negative* rod; nor did the *negative glow* vary. Whether the *negative* end were inductive or inducteous, the same effect was produced. It was strange to see the *positive* purple haze diminish or lengthen as the ends were separated, and yet this *dark space* and the *negative glow* remained unaltered.”

As might have been imagined, a great variety of opinions have been entertained as to the chemical nature *per se* of the *Electrical Fluids*; and in the absence of any positive knowledge

on the subject, it is yet interesting to know, that some very shrewd guesses have been thrown out. The subtraction of oxygen from the atmosphere, and the absolute necessity for the appropriation of that agent, or of some other supporter of combustion, by the elements of the Galvanic Battery when in action, led Fabrini, Colonel Haldane, and others, to suppose that some unknown transformation of part of such agents occurred. Others have entertained the idea, that the *latent light* which must accumulate in the Planet assumes the form of *Electricity*:—and both these opinions gain a certain weight from the fact, that active electricity has in itself the power of producing the most intense combustion, both in *vacuo* and in *nitrogen gas*—and thus, in the absence of any external supporter of ignition, light and heat are developed:—and if charcoal is submitted to the action of the fluid, the prismatic colours occur in succession, supplying even some of the rays which are deficient in the solar beams. In proof that this light is the immediate product of the electrical stream, it is remarked that, during its intense development, the charcoal is found to have lost very little of its weight; and that neither it, nor the gas employed, have undergone *any chemical* alteration.

I have promised to say something on the subject of Secretion, but we have as yet, no certain data explaining the peculiar action of the Electro-Forces in effecting this function. On the other hand, much is known of the natural and artificial means of increasing and controlling the action of the secreting organs :—and something may be said of their Electricity. In the latter respect, we have an interesting example in the action of the *Lacrymal Glands*.

Successive ages have left the phenomena of *Tears* without any physiological explanation—or indeed, anything more, than the common and trite remark, that weeping serves as a relief in circumstances of pain, or under the extremities of grief, or of joy : this is all very true, but it may be inquired—how is this relief effected ? —We answer that *tears* form, as it were, a *safety-valve* to the brain !—that they discharge its super-abundant Electricity in moments of intense action. When once mentioned, this result is so self-evident, as not to require farther explanation, for who has not felt the heat of *tears*—in popular language “Hot scalding Tears !”—and what is heat, but electricity ?

Of the signal influence of Galvanism in augmenting the Secretions, we have already spoken in treating of the Liver ; and from thus exciting

other glands, I have also had very marked effects;—for instance, I have drawn no less than an ounce and a half of saliva, by measure, from the *parotids*, in eight minutes, and in an instance when the evacuation was of great service to the patient. Of its influence on the kidneys, we have also evidence, in the relief of diabetes.

To Dr. Marshall Hall we are indebted for a statement of the interesting fact, that emotions of a *pleasing nature increase* the secretions, and thus augment the strength; while the *excretions* occur in greater quantity, under feelings of *depression and of sorrow*, and when, indeed, wasting and sickness too often ensue.

To pass on to another subject, we may observe, that all students of physiology are aware of the difficulties which have occurred in attempting to explain the phenomenon of *Muscular Contraction*; and even with the conviction, that Electricity was the motive power, the explanations have not been satisfactory. The most circumstantial, and to a certain extent true, but still not sufficient, because there are muscles of great importance to which it will not apply, was the theory brought forward by M. M. Prevost and Dumas, and shown on the delicate muscles of the lower jaw of the Frog.

The Electrical Law depended upon is this—Parallel conductors of electrical streams attract each other, when pervaded by the same electricity, moving in the same course.—Thus, a wire bent into spiral rings like a spring, and suspended on a line of silk, passing freely through its centre, will contract on itself, whenever a current of electricity is thrown upon it, and again expand, when that current is withdrawn. Now it is evident that if any number of light non-conducting cotton threads were fixed in horizontal lines, from ring to ring, along the wire, that whenever the wire contracted, these lateral threads must be shortened too, and also thrown into angles at each of the bends.—Now call the wire a *nerve*, and the cotton threads, *muscular fibres*, and you have a full explanation, or rather a working model of the contractile action which these physiologists describe.

M. M. Prevost and Dumas refer to the finer divisions of the nerves, as taking a course at right angles with the muscular fibres, each branch returning with a loop-like link, to the trunk from which it springs, or anastomosing with that of some other nerve: and they observe that the muscular fibres assume a zigzag form, at the moment of contraction; the angles

corresponding with the points at which the fibres are crossed by the nervous filaments.

It will be noticed, that the muscles alluded to in the frog, are in the strongest sense, those of *voluntary motion*; as that animal in taking its insect prey, often opens and shuts its jaws with a rapidity which the eye can hardly follow.—It is probable, indeed, that these nervous arrangements only exist in certain instances of muscles of the same class:—it is certain, at least, that in most of the powerful *involuntary muscles* of organic life, the distribution of nerves is altogether insufficient for the purpose.

On the whole, notwithstanding the explanation already given, the difficulties of the subject were nearly as great as ever; and it appeared to me, that they were only to be surmounted by a careful study of the effects which an application of the leading laws of the Electro-Forces to the organic structure of the ultimate muscular fibre would present.

For some valuable views of the minute anatomy of the structure in question, we are indebted to Dr. Hodgkin and Mr. Liston; particularly as to the fact, that each fibre is an uninterrupted thread or cylinder: but, for a full and satisfactory description of “The Elementary Structure of the Muscular Fibre of Animal and

Organic Life," we have to thank Mr. Frederick Skey, a profound anatomist, and one of the most successful Operative Surgeons of the day. His investigations confirmed the previous observation, that each fibre was a continuous thread or cylinder,—with the addition, that the fibres of the muscles of *voluntary motion* are crossed at different distances by striæ, varying "in thickness and number," which "appear to bind together the united strands of the fibre, they are the woof to the warp of the longitudinal filaments."—Now, the filaments are cylinders filled with a glutinous substance—"each is connected with its fellow by cellular membrane, still finer than that which connects the smaller fasciculi, and so transparent as not to impair the distinct view of the fibre itself."

This, it will be observed, is precisely the distribution of substances of *different conducting capacities*, which we find to be adopted in all instances where a direct Electrical action is the object, as in the cells of the Torpedo. In the muscular fibres, destined to the purposes of involuntary motion, the cellular tissue is less apparent; there are no distinct, or separate fibres, but the filaments are interwoven to form the general structure; and there are no transverse striæ, except slightly in the instance of the heart.

In all the above examples, the structure of the fibre is still the same, as to its being a *cylinder, containing a glutinous substance*, and therefore, the fibres are all subject to the Electro-Law we are about to name,—with this proviso, that its force may be directed, in the voluntary muscles, and increased in all, by the Electro-Nervous Influence which would furnish the stimulus of *intensity* to the previous charge of *quantity*.

Now the Electrical Law alluded to, as the immediate cause of *muscular contraction*, is at once the most simple and comprehensive; it is that of *Expansion*. The shivering of glass vessels from the increased volume of mercury confined within them, and the swelled and raspberry-like appearance of a small drop of blood, when under this influence, are common experiments; and when we consider, that each muscular fibre is an elastic cylinder filled with a substance capable of a similar *expansion*, we see at once, that the operation of such a force must be to swell it; and as the sides are the weakest part, the swelling will be greatest in the centre, and the whole will be shortened—or in other words, it will contract upon itself.

This condition of a *contracted muscle* is evident to the eye, its convex and thickened form

not admitting of any conclusion that does not explain this swelling of the centre, which gives to some muscles when contracted, an almost globular form.

The Electricity necessary for this purpose, doubtless arises, in the first instance, from the transformation of the tissues, as already explained on the data of Liebig; and by the change of the blood, from the arterial, to the venous condition;—and these supplies would keep the muscle in the necessary state of Electro-Tension, and the sudden addition of an extra charge, by the nerves, would throw it into action; the surplus escaping on the compression which follows, partly as heat, and partly to increase the transformation of the tissues, which is always augmented by muscular exertion.

Beyond these phenomena, there is a third source, or rather cause of Electrical Accumulation, in the muscular tissue: and this is the *impulsive concussion* of the *arterial action*:—every beat of the pulse being an active force, which, when the general Electro-tension of a muscle is considered, must lead to the extrication of *free electricity*, the quantity augmenting with each progressive action, and escaping by discharge, when the surplus has reached beyond a certain point.

I consider, indeed, that this arterial impulse is in itself the leading source of action, in some of the muscles of *involuntary motion*, the order of their contractions being, to a certain extent, in accordance with the condition of the pulse,—and so varying in different individuals. In effecting the function of Respiration, the muscles may be considered to be of a compound order; in part voluntary, and in part, automatic: and taking the pulse at seventy-two in a minute, and the respirations at eighteen, we have four impulsive actions of the arterial system on the parts implicated, for every contraction. And here again, it should be remembered, that the action of the heart is, in a great measure, regulated by the function of respiration; so beautifully are the equilibriums of nature maintained.

Of the importance of *Adipose Tissue*, as a non-conducting medium to preserve the due concentration of Electricity in the glands and muscles, we have already spoken; but still it may be proper to remark, that in the instance of the bowels, in which a constant automatic action is of great moment, we find Electro-Retention amply provided for, by the presence of *fat* between the layers of the mesentery and the omentum.

In individuals advanced in life, there not un-

frequently arises a comparative torpor, or want of due contraction in the muscular coat of the *bladder*, which does not then act, unless the organ is unduly loaded; a condition in many ways injurious, but which I have found invariably to give way under the influence of Galvanic Treatment. In instances where a want of contractile power in the *sphincter vesicæ* has arisen from other causes, it has, by similar means, been readily relieved.

As *Stone* and *Gravel* are, in fact, secondary symptoms arising from a peculiar state of the general System, causing the irregular secretions in which the local formations and consequent suffering have their origin; it occurs as a natural consequence, that with the amended health which follows a course of galvanic treatment, when addressed to the digestive organs, that these complaints if present, are to a certain extent relieved; and that in the case of *gravel*, the relief may be efficient. In the instance of *Calculus*, however, if the earthy concretion is of any size, we have a separate disease of a formidable class, and one which, in the present state of medical science, only admits of cure by Surgical Operation; that operation, being either the extraction of the stone by the forceps after an incision by the knife—or, the boring into,

and crushing down of the stone, by means of a most ingenious mechanical contrivance which is introduced into the bladder by the *urethra*, and there expanded so as to catch hold of the Stone, and retain it during the perforation, and is then made to crush it by the compression of its tentaculæ. It will be observed, that in this case there is no knife, and no incision,—but on the other hand, the indispensable size of the apparatus, renders its introduction a matter of fearful moment, as the pressure, in some instances, produces great pain; there is too a chance of laceration of the bladder; so that, after all, there is but little choice; and many of our best surgeons have considered the knife as the less formidable instrument of the two.

It will, indeed, be a triumph to humanity, if Electro-Physiology should enable us to remove the cause of this terrific and agonizing disease, *without* either *pain*, or *danger* to the patient; and I have a confident hope, that the practical advances I have recently made in the local treatment will ultimately enable me to accomplish this object in the great majority of cases.

The Reader will at once perceive, that I allude to the chemical decomposition of the *Urinary Calculi* within the Bladder. In the human organ, already in a tender and morbid state from

the irritation of a *calculus*, the obstacles have been hitherto insurmountable, although it has been proved by M. M. Prevost and Dumas, no less than twenty years ago—for the account of their practical investigations on this subject appears in the “*Annale de Chimie et de Physique, Juin 1823*”—that, the *Galvanic Decomposition of Urinary Calculi* within the *Living Bladder* is both *safe* and certain. In the first instance, they found that, when a *Urinary Calculus* was introduced into the bladder, and operated upon with a Galvanic Battery of one hundred and thirty-five plates, no uneasiness was shown by the animal:—and in another instance, having operated “for an hour twice daily during six days,” in which period the calculus used lost one-eighth of its weight, and was become “*so weak and brittle*, that it could not be again introduced into the bladder”—yet that still, the operation was perfectly *safe* and easy—they observe, “The animal was killed a few days afterwards, and the bladder was found to be *quite free from injury or disease*.”

It is satisfactory to add, that I have surmounted the first and one of the greatest difficulties, by the invention of guarded *Flexible Conductors of Mercury*, that pass into the bladder with the same perfect facility and safety

to the patient as the gum catheter,—and which are capable of conveying any degree of Electro-Force that may be requisite for the decomposition of the Calculus.

The beneficial influence of Voltaic Electricity is in no case more apparent than in affections of the *Uterine System*. It gives ready relief in many instances of *Dysmenorrhea*; and it is peculiarly useful to persons who suffer from that relaxation and weakness which sometimes ensue from frequent child-bearing; and which, when neglected, are frequently followed by that distressing symptom, *prolapsus uteri*.

The Electro-Physiology of the *Sexual System* would next present itself to our attention;—but it will be obvious to the Reader, that this subject should form a separate Treatise. At the same time it may be observed, that, from what has been said of the Electro-Condition of the nervous and vascular tissues, the medical student will be enabled to draw some evident and important deductions on this subject;—and it may be added, that such new views will strengthen the opinion, that celibacy is not only an unnatural condition, but one too often actively injurious to both the body and the mind.

Having reached the limits which he had prescribed to himself as the extent of his present work, the Author cannot but acknowledge the delight it has afforded him in its composition; and that simply as it has unfolded some of *the controlling energies and predisposing sympathies of the Creation*. Nor let him be charged with arrogance in this avowal. He who will stand in silent, watchful humility before the shrine of Nature, even as a little child hangs at its mother's knee in fond confiding hope, will never watch in vain. The Leading Laws which it has pleased the DIVINE ARCHITECT to mark out for Himself, are as strains of distant music; the hasty passer-by regards them not, but he who listens deeply, if he catch but one, will comprehend the rest; for each is essential to the whole, as one continuous harmony; and so with the facts of science; the one leads us to the other by an inevitable induction, as it were, without our labour or our care;—

“ALL ARE BUT PARTS OF ONE STUPENDOUS WHOLE,
WHOSE BODY NATURE IS, AND GOD THE SOUL.”

POPE.

Having reached the limits which he had
prescribed to himself as the extent of his pre-
sent work, the Author cannot but acknowledge
the debt he has contracted him in the composi-
tion; and that simply as it has indebted some
of the controlling energies and arrangements
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out for himself, as a series of distinct numbers;
the busy passer-by would deem not for the
who listens deeply, he can catch but one will
comprehend the rest; for each is essential to the
whole, as one continuous harmony; and so with
the facts of science; the one leads us to the
other by an inevitable induction, as it were
without our labour or our care;

"All are not parts of the system which
which most Nature has made good."

APPENDIX.

ELECTRO-PHENOMENA OF SURGERY.

THE significant expression that a patient has '*slipped through the fingers*' of his medical man—viz. that he has died unexpectedly, and without apparent cause, is sufficiently understood ; and experience shows, that such may often be the case—the reason alleged has been, that there was "something peculiar in the constitution ;" a reason which of course amounts to nothing :—and again, operations are declined,—as in the case of the small tumour on the head of George the Fourth, avoided by Sir Astley Cooper—that are trifling in themselves, but dangerous from the secondary symptoms they may arouse : — the explanation has been the usual constitutional nonentity. Now ELECTRO-PHYSIOLOGY would teach us, that the unsuspected fatality in the former case, and the secondary symptoms in the latter, are in all instances, an undue *transfer*, or *loss* of Electro-Force which may be often foreseen, and guarded against ; and the following striking case, which occurred in the County Hospital, at Gloucester, will be found to illustrate our proposition.

"An operation was undertaken by Mr. Cother, on a young woman, in order to relieve a *locked jaw* of many days—and a *paralysis* of the entire left side, of many weeks standing, by a free incision of the *scalp*, all other means having failed : —The loss of blood was certainly large, but *not sufficient* to account for the extreme exhaustion which ensued ; the symptoms of which, became so alarming, that no hopes were entertained of the patient's recovery :—wine, brandy, ammonia, opium, and warmth in every form, were used in vain ; the pulse ceased to be felt at the wrist, and momentary dissolution was expected. At this time, the operator directed some

oxygen gas to be administered, and in less than *ten minutes*, the pulse was again perceptible, and the powers improved.

It was at this moment a beautiful sight, to see the arm which had been previously paralysed, drawing to the nostrils the vessel of reviving vapour, as it would have carried to the lips of the parched, the cup of refreshing liquid. In a few hours, the patient rallied, and the case was successful."

Gloucester, April 12th, 1831.

In this instance, the paralysis of the side had placed the opposite hemisphere of the brain in an irregular state of electro-accumulation, and the sudden discharge arising from the hemorrhage on the incisions of the scalp, left the *gastro-pneumatic* and *sympathetic* nerves without sufficient energy to carry on the functions of respiration, so that death would very soon have ensued:—But at this awful moment, the oxygen gas was given, and the patient was saved!—Now we have to enquire into the *principle* on which this great result was obtained:—the old answer would have been, "by the vivifying influence of the gas,"—to which we may subjoin with Hamlet,—"Words! words! words!"—The renewed life, arose from the electricity extricated by the formation of the carbonic acid gas, on the union of the oxygen with the carbon, as explained at Pages 127-128 of the present work, under the function of respiration.

I cannot dismiss this case, without observing that many deaths from a similar exhaustion of vital power might be prevented in our Hospital practice by the timely inhalation of oxygen gas; of course duly mixed with atmospheric air.

Of the misdirection, and sudden expenditure of Electro-Force, and that often to a fatal extent, from apparently inadequate causes, we have frequent examples in the wounds arising from scalds, and burns. In these cases, the capillary vessels, and nerves of the surface, are more or less the seat of the local injury, and from the highly electrical nature of their functions, the violence done to a spot no larger than the palm of the hand, will often arouse the whole capillary

system of the body into a state of preternatural activity ; causing stupor by overcharging the circulation of the brain, and impeding respiration, by an engorgement of the lungs ; —and besides these symptoms, there is often an insidious waste of *electro energy* from the abraded surface, which drains away the very life !—All the real remedies have a tendency to check this waste ;—the oily preparations as non-conductors—and the dry flour, by its marked *electro positive* state when *cast* upon the surface. It is this quality that renders it so decidedly useful in retarding ulceration ; as it coagulates the lymph which so rapidly exudes on these occasions. Of the internal remedies, there can be no doubt as to the value of opium, and of cordials.

Of the vital character and importance of the blood, almost every second page of this work has borne evidence, and it is hardly needful for me to add that I am most deeply impressed with a sense of the ruinous consequences which follow in the train of the lancet.—There are very few instances that can justify general bleeding—but, in the judicious use of leeches, and the other modes of *local* bleeding, much good may be obtained :—I say *bleeding*, not *depletion*, —for the object with me, is not so much to take away blood, as to open a path for the escape of the electricity accumulated in the capillaries of the inflamed part ;—and this desirable object is frequently obtained by the sympathy between the superficial and more deeply seated vessels of this order ; —a sympathy, which nothing but their *electrical character* could account for, and which on any other grounds but those of Electro-Physiology would be altogether a mystery.

Under these views, it is evident that in all injuries—as stabs, gunshot wounds, or heavy blows—affecting these tissues, and attended with extravasation, the *immediate* use of local bleeding by leeches, or scarification, should be had recourse to :—To wait for the appearance of “secondary symptoms,” if the case is serious, is but to seal the doom of your patient ; —all after-bleeding in such cases may palliate the symptoms, but will only hasten the fatal result.

HYDROPHOBIA CURED BY GALVANISM

BY PROFESSOR ROSSI OF TURIN.

THE following case is quoted from Dr. Wilkinson, who relates it at page 453 in the first volume of his "Elements of Galvanism," as the substance of a "Report" made by Vassalli Eandi on the Medical Agency of Voltaic Electricity. The simplicity of the narrative carries a conviction of its truth; and it should also be observed, that the Electro-Force employed, was one of commanding power, the fifty disks used for the pile at Turin being each six inches in diameter; so that the effects of *quantity* and of *intensity* were present to a considerable extent, and that with *accumulation*. It will be noticed that the reaction was unusually severe from the excitement of the disease.

"The advantages of Galvanism will appear to you still more decisive from the cure of a person labouring under Hydrophobia, performed lately by M. Rossi.

"A man bit in the finger by a mad dog came to consult him in consequence of a pain which he felt in the arm, the back, but particularly in the finger, which had been bitten more than a month before. A caustic applied to the finger had removed the pain; but a few days after it returned, accompanied with symptoms of hydrophobia. The patient could no longer look at water without horror; an inflammation in the throat prevented him from swallowing even chewed bread; and he experienced a strong propensity to bite those who were around him.

"In this state he was brought to M. Rossi, who, observing that he could not bear the sight of water, nor even that of shining bodies, provided in another room a pile consisting of fifty pairs of plates of silver and zinc, intermixed with

fifty pieces of pasteboard moistened with a solution of muriate of ammonia.

“ He employed slips of brown paper as a conductor, on which the naked feet of the patient were placed; and at the moment when he opened his mouth to bite, one end of the arc was thrust into it, while the other communicated with the pile. The patient suffered a great deal from this operation, which, after several shocks, weakened him so much that he could no longer support it. Being stretched out on the floor, he was then galvanized with ease. The operation made the sweat run from him in drops.

“ After some time, M. Rossi caused the patient to be conveyed home; and gave orders that he should be brought back the next day, to the end that the operation might be repeated. It was two o'clock in the afternoon when the patient was galvanized, and at six the next morning he came to Rossi himself, to tell him that he was completely cured, as he experienced no pain or difficulty of swallowing, and was entirely free of his aversion to water and to liquids.

“ But, a few days after, some slight pains having given him reason to apprehend a new attack of hydrophobia, he returned to Rossi, who, by repeating the operation, made all the symptoms disappear. This cure was effected in the presence of several persons. This patient, for a month after, could feel shocks up to the shoulders which I could feel only to the articulations of the finger joints.”

THE ELECTRICAL PHENOMENA OF CONTAGION.

THE subject of Contagion is one of such infinite moment, that the reader may probably be desirous of referring to the letter alluded to at page 197, as having appeared in the Times Journal.

The communication in question, headed "PREVENTION OF FEVER," was printed Jan. 20, 1842; and was signed, "*A Surgeon, Cheltenham.*"

Without any allusion to the electrical reason, the writer proves, that *the anointing of the body with oil or unctuous substances, is a preventative of Fever*:—and in evidence of the fact, he shows that the natives of tropical regions who pursue this practice, are exempt from the local fevers so fatal to Europeans:—and secondly, that those persons in Turkey, who are engaged in the practical part of the oil trade, are equally *exempt* from the visitations of the Plague:—and again, that the tallow chandlers of London, during the prevalence of that awful disease, were altogether *free* from its attacks:—And he then very cogently observes;—"Here are three totally distinct classes of men having no one thing in common, except greasy skins and a freedom from infection."

A second communication, but from another correspondent, appeared on the 22nd of the same month, under the signature, "J. R. J."—This writer corroborated the views of the former, by citing the fact, that during the great Plague at Malta, the commanding officer of one of the regiments of the garrison having heard of the *escape* of the *oil porters* on the opposite coast, ordered his men to dip their shirts in oil every morning, and after wringing, to wear them in this *greasy state*; they did so, and escaped the mortality that devastated the Island.

On the whole, nothing can be more conclusive than the above evidence in confirmation of the fact, that the *anointing of the body*, will prevent the contamination of pestilential fevers; and for an explanation of the scientific data, on which the exemption depends, the reader is referred to the present work.

ABSORPTION.

IT is related, that Harvey could find no physician past forty who would believe in the Circulation of the Blood! The slow advance of Electro-Medical Science has been an equal triumph of prejudice. Had it not been so, the simple fact that this agent will remove a chilblain, known fifty years ago, would have shown to every physiologist its all-commanding influence in the process of *Absorption*. It would have been as the apple of Sir Isaac Newton,—the proof of an invaluable principle. How then does Electricity remove a chilblain? We answer, by giving an *increased contractile power* to the arteries, and greater *activity to the absorbents*. Now as it is ascertained that, in all instances of low or chronic inflammation, there is a loss of tone and consequent dilatation of the minute vessels, the general application of the principle in question is self-evident. It is, indeed, certain, that the relief under galvanic treatment in cases of *Hemiplegia*, and in some other forms of *palsy*, is by the removal of impediments to the free circulation of the Brain.

The subjoined List of Cases has been extracted from the GUY'S HOSPITAL REPORTS, and forms a portion of the evidence there given from the books of the Hospital. It will be observed, that the results are most satisfactory; and they are equally so in the cases of Paralysis, which also appear in the Report. The extracts here given were selected, as they illustrate two of the leading principles already explained in the present work—First, the influence of Electricity on the Nerves; and Secondly, on the Vascular System.

CASES OF NERVOUS DISEASE attended with more or less *involuntary* muscular Action, and in that last particular comprehended in medical language, under the term Chorea.

No.	Name.	How long ill.	Character.	Apparent Cause.	Results.	Under whom	Where treated.
1	Francis Shead	12 3 weeks	Universal	Fright	Cured	Dr. Addison	Guy's In-patient
2	Sarah Kidd	16 12 months	ditto	Sudden arrest of the catamenia	ditto	ditto	ditto
3	Jessie Wick	14	Complic. with epilepsy	Fright	ditto	ditto	ditto
4	Emma Hillier	14 4 years	Universal	Epileptic fits	ditto	ditto	ditto
5	Ann Baker	21 2 years	Complic. with epilepsy	Excessive loss of blood in a previous disease	ditto	ditto	ditto
6	William Sutton	14 6 months	Universal	Fright	ditto	ditto	ditto
7	Harriet Witham	8 6 weeks	ditto	Rheumatism	ditto	ditto	ditto
8	James Treeby	18 2 months	Confined to right side	Exposure to cold	ditto	Dr. Bright	ditto
9	George Eden	12 4 weeks	Universal	Fright	ditto	Dr. Addison	ditto
10	William Price	12 .....	.....	.....	ditto	.....	ditto
11	William Jordan	12 10 months	Universal	Irritation of tænia	ditto	Dr. Back	ditto
12	Joan Corbyn	14 3 months	ditto	Terror from confinement in a cellar	ditto	ditto	ditto
13	Sarah Watts	... ..	.....	.....	ditto	.....	ditto
14	Mary Smith	9 5 weeks	Universal	Intestinal irritation	ditto	Dr. Addison	ditto
15	Moses Mills	9 14 days	ditto	Fright	Relieved	ditto	ditto
16	Maria Phipps	18 3 weeks	ditto	Terror from a dream	ditto	Mr. Stocker	Guy's Out-patient

17	Eliza Trimming	19	1 month	ditto	Fright	Cured	Dr. Hughes	ditto
18	Eliza Raven	16	3 months	Confined to right side	Amenorrhœa	ditto	Dr. Addison	Guy's In-patient
19	Eliz. Edwards	17	5 months	Confined to upper extremities	ditto	Relieved	ditto	ditto
20	Robert Carr	15	?	Confined to right side	Intestinal irritation	Cured	ditto	ditto
21	Martha Dupy	11	3 months	Confined to left side	Fright	ditto	Dr. Bird	Guy's Out-patient
22	Christr. Calthorpe	8½	?	Universal	ditto	Left from alarm	Dr. Addison	Guy's In-patient
23	Emma Stroud	14	4 months	ditto	ditto	Cured	Dr. Babington	ditto
24	Sarah Wheeler	12	5 weeks	Confined to right arm	ditto	ditto	Dr. Back	ditto
25	Henry Mason	40	.....	Confined to muscles of the neck	Exposure to intense cold	ditto	Dr. Bird	Guy's Out-patient
26	Caroline Deacon	9	2 months	Universal	Terror from confinement in a cellar	ditto	ditto	ditto
27	Mary Shearman	15	2 months	Confined to right side	Terror from the house being on fire	ditto	ditto	ditto
28	Mary Coffee	9	?	Universal	Fright	ditto	Dr. Addison	Guy's In-patient
29	Benjamin Smith	61	5 months	ditto	?	No relief	ditto	ditto
30	Emma Kenney	11	?	.....	Fright	Cured	Dr. Babington	ditto
31	James Townsend	40	2 years	Confined to lower jaw	Mechanical injury	Relieved	Mr. Callaway	Guy's Out-patient
32	James Spriggs	39	39 years	Confined to hands and fingers	Congenital	ditto	Dr. Bird	Finsbury Dispensary
33	John Brett	14	4 months	Universal	Epilepsy	Cured	Dr. Addison	Guy's In-patient
34	Eliza Jay	11	1 year	ditto	Grief	ditto	ditto	ditto
35	James Button	8	5 months	ditto	?	ditto	ditto	ditto
36	George Baker	13	10 weeks	Confined to right side	Fright	ditto	Dr. Babington	ditto

CASES OF AMENORRHEA.

No.	Name.	Age.	Ill.	State of general health.	Result.	Under whom.	Where treated.
1	M. Williams	15	never men- struated	Chlorotic	No relief	Dr. Ashwell	Guy's In-patient.
2	Mary Evans	17	3 months	ditto	ditto	ditto	ditto.
3	M. Crighton	16	never men- struated	ditto	ditto	Dr. Addison	ditto.
4	Mary Dawes	14	ditto	ditto	ditto	Dr. Ashwell	ditto.
5	Har. Ibrock	16	?	Slightly chlorotic	Cured	ditto	ditto.
6	S. Bunday	16	10 months	Not chlorotic	ditto	ditto	ditto.
7	E. Boldock	18	3 months	ditto	ditto	Dr. Addison	ditto.
8	A. M'Guavin	18	1 year	ditto	ditto	Dr. Babington	ditto.
9	S. Green	21	3 years	Slightly chlorotic	ditto	Dr. Ashwell	ditto.
10	Emma Laard	19	5 months	Hysterie	ditto	Mr. Lever	Guy's Out-patient.
11	M. Burgess	19	1 year	Slightly chlorotic	ditto	Dr. Bird	ditto.
12	Car. Watts	18	5 weeks	Not chlorotic	ditto	ditto	ditto.
13	E. Maston	16	never men- struated	Slightly chlorotic	ditto	ditto	ditto.
14	S. Burrow	19	2 months	No chlorosis	ditto	ditto	ditto.
15	S. Parker	16	8 months	ditto	ditto	ditto	ditto.
16	M. Winman	19	6 months	Slight chlorosis	ditto	ditto	ditto.
17	Betsy Ryan	17	10 months	ditto	ditto	ditto	ditto.
18	S. Glasscock	25	8 weeks	No chlorosis	ditto	ditto	ditto.
19	M. Freeburn	16	8 months	ditto	ditto	Mr. Lever	ditto.
20	M. Witchett	16	6 months	ditto	ditto	Dr. Bird	Finsbury Dispensary.
21	E. Mind	16	6 months	ditto	ditto	Mr. Lever	Guy's Out-patient.
22	E. Cathrie	20	?	Hysterie	ditto	Dr. Bright	Guy's In-patient.
23	M. Boulchin	17	3 months	No chlorosis	ditto	Dr. Addison	ditto.
24	E. Boyce	24	2 months	ditto	ditto	Dr. Bird	Finsbury Dispensary.

SUSPENDED ANIMATION.

IN cases of attempted suicide by hanging ;—in the lethargy following poisoning by opiates, and the injuries from burns ; the use of Galvanic agency in arousing the function of Respiration is of the first importance. On the other hand, in instances of drowning, although still *warm*, the patient is too often *dead* ; the innate vital electricity having been dissipated, with vascular concussion of the brain, in the last convulsive struggle—when, on the principles explained in the Third Chapter of this work, no capacity for galvanic excitement remains.

In the absence of ELECTRO-PHYSIOLOGY, strange mistakes have been made in the latter instance ; and some years ago the Royal Humane Society had a Galvanic Battery, from which nothing less was expected than that it would *revivify the dead* ! Not having been found *quite* available for this purpose, it is to be feared that Electro-excitement has been neglected in cases of *suspended animation*, in which, together with artificial respiration, it would be of infinite advantage.

PHYSIOLOGICAL EXPERIMENTS.

IT will be seen, that in the present work, the author has drawn his conclusions rather from the actual phenomena of Nature, than the analogy of experiments :—on this point agreeing with Liebig, that—“The most exact anatomical knowledge of the structure of the tissues, cannot teach us their uses ; and that from the microscopical examination of the most minute reticulations of the vessels, we can learn no

more as to their functions, than we have learned concerning vision, from counting the surfaces on the eye of a fly.”—*Preface to Animal Chemistry*, p. 9.

But still there are experiments of the first moment, and perfectly conclusive;—those by Dr. Wilson Philip, on the eighth pair of nerves, are of this order; and these, having been ratified, do not require to be repeated.

As a general rule, experiments on living animals should not be made, except all other means fail in approaching results of vital importance; and very fortunately, investigations on animals recently killed, but in which the *electro-forces* of the *Capillary System* are still in action, are often equally satisfactory, and I have never found it necessary to make any other.—In instances of the former nature, the advice of Dr. Marshall Hall, will certainly be followed by every man of honourable feeling—viz. “that animals should be selected of the lower grade as to intelligence;”—and when possible, should be rendered insensible.

That *domestic* animals of so high an order as the dog, should ever have been submitted to such experiments, is certainly a very humiliating reflection:—that they are obtained cheaply, because *stolen*, is a reason that no *gentleman* would like to acknowledge.—On the whole, I cannot but presume that parties making such experiments, were ignorant of the *high intelligence* and *grateful affection* of the dog,—for to admit that a man with this fore-knowledge would torture such an animal, is to suppose him to be capable of any atrocity.

FINIS.

