ON THE

RELATIONS WHICH ELECTRICITY SUSTAINS TO THE CAUSES OF DISEASE.

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THE influence of electrical fluctuations as a cause of disease is known to some of my friends to have long occupied my thoughts, and on several occasions I have endeavored—vainly as I supposed—to invite to it the attention of my medical brethren. My unexpected appointment, therefore—for though a delegate to the Association[1] it was not in my power to be present at its meeting—as a committee to report on this subject, I regard as a proof that so far from having been a mere "*vox clamantis in deserto*," with no assenting response, my humble efforts have not been so entirely overlooked as I had imagined; and I accept it with pleasure as affording at once a larger auditory, and insuring for the views which I have to present a more formal and considerate hearing. Happy if I shall succeed in exciting the interest of the profession, and awakening such a general spirit of inquiry and reflection as may lead either to their rejection or to their fuller development and confirmation.

It is easier to indulge in conjecture and to frame hypotheses than to observe closely and reason correctly, and hence in every age, crude and unfounded assumptions have retarded the progress of science. Medicine, a branch of knowledge in which from its very nature—conversant as it is with the living organism whose ultimate workings no eye can penetrate—direct experiment is always difficult and often impossible, constitutes no exception to the truth of this remark. It is especially applicable to that department which treats of the etiology of disease; and much of the uncertainty and irresolution that prevail on the invasion of any new epidemic are rightly attributable to this cause. Theories framed in the infancy of science, and transmitted unquestioned from one generation to another, are still blindly adopted, and implicitly followed, though their inconsistency with facts of daily occurrence

[1] At its meeting in 1864.

can hardly have escaped the observation of the intelligent and reflecting. Nor have the speculations of a later age been more rational and philosophical. The most fanciful notions have been promulgated even in our own day; which while often inferior in ingenuity to their venerable prototypes, do not possess the merit, which they really had, of classifying, and, with some plausibility, of explaining, the phenomena. Of this kind, among many others, is the visionary supposition which ascribes to certain epidemic diseases an animalcular origin. If in our reasoning upon this subject we could discard the fallacies and prejudices of education, with the idle vagaries of imagination, and look at what is passing around us in the increasing light which modern investigation is shedding upon much that has hitherto been dark and inscrutable, we could hardly fail to form a judgment at once more in accordance with the nature of the animal economy, and the dictates of common sense; and our practice on such occasions would not only be less tentative and empirical, but simplicity and order would be seen, where all is now intricacy and confusion.

One of these baseless assumptions is the doctrine of atmospherical poisons, or miasms, as an ordinary cause of epidemic and endemic diseases; a doctrine which has become thoroughly incorporated with our literature, and forms a part of daily medical thought and expression. In books, in lectures, in conversation—everywhere—it is the recognized language of physicians; and those who should have the temerity to intimate a doubt of the truth of a tenet thus universally admitted, would incur no small risk of having their own sanity questioned in turn. And yet, notwithstanding this prescription and assurance, it is not hazarding very much to say, that the opinions prevalent on this subject are not only unsound, but are hardly creditable to us as members of a learned profession; because they prove that we have neither been careful observers of facts, nor been guided in our reasoning by sound principles of philosophy. It is a maxim in logic not to assign more causes for the production of any given effect than may be necessary for that purpose; a restriction we have wholly disregarded in treating of subjects which, from their connection with the important matters of human life and health, demanded the most careful scrutiny and rigid deduction; and, ignoring the constitution of the animal frame, as well as the influence of elements analogous to the nervous force, have needlessly invented a different origin for almost every departure from the healthy state.

Modern researches have partially developed the wonderful simplicity which characterizes all the operations of nature; a divine economy, if I may so speak, is everywhere conspicuous; results the most diverse and extraordinary are produced by the combination in different proportions of a few apparently elementary bodies; and we are warranted in believing that, as our knowledge increases, this simplicity will be still more strikingly displayed. Why should not the same be true also of the animal economy? It is a complex and intricate structure, composed of many different tissues and organs, varying somewhat in their manifestations of individual life, but all subjected to the control of a central power—the brain—having innumerable prolongations conveying its subtle intelligences to and from every part; and from any morbid change in the action of which manifold deviations from a normal condition might, *à priori*, be anticipated. How much more philosophical, then, to recognize the instrumentality of a single principle of kindred subtlety and essence, evidently capable of producing such change, than unnecessarily to multiply causes, and invoke the interposition of as many agencies as there are diseases in the nosology! We have imaginary miasms—several of them supposed to be often contemporary in their existence and even to be operating simultaneously in the same individual—for the various exanthemata, for influenza, for diphtheria, for cholera, for dysentery, for each of many different kinds of fever, for hooping-cough, and for every epidemic by which we are assailed! In accounting for the phlegmasiæ, it is true, we are accustomed to veil our ignorance and to flatter our vanity under the convenient and comprehensive phrase of "taking cold;" an expression, however, to which we attach no very definite ideas; and which, in its literal sense, the commonest observation shows to be incorrect in most of the cases to which it is applied.

An etiology so multiform cannot be true; and if the abnormal consequences may, in very many cases, be more rationally and satisfactorily explained through the operation of a single principle, it must be abandoned. We are erroneously taught by it to expect some diverse effect peculiar to each imaginary poison; whereas the diversity and the peculiarity reside not in the external agent, but in the different tissues and organs of the system acted upon. The poisons thus falsely believed to be admitted into the circulation are, further, supposed to create a kind of fermentation, or change in the blood, and subsequently to break forth in various

morbid manifestations. Nothing, in my judgment, is more gratuitous and unfounded. On the contrary, I believe that it is upon the nervous system, and not upon the blood, that the impression is primarily made. The blood derives and maintains its vitality through its connection with that system, with the minute ramifications of which it is everywhere brought into contact; the nervous influence it thereby receives is necessary to its healthful constitution; and when this is greatly impaired, or rudely subverted, it loses its property of coagulation, and falls, of course, into a state of dissolution; of which we have examples in the passive hemorrhages, purpura hemorrhagica, etc., and a very forcible illustration in the case of persons killed by lightning.[1]

I have dwelt the longer upon this subject, because few fallacies have had greater influence in retarding the progress of medical science than this venerable and stereotyped doctrine of the old humoral pathology. It is, I am fully convinced, one of the chimeras handed down to us from days of comparative ignorance, when physicians, unacquainted with the laws of life, and unaccustomed or unwilling to think for themselves, received with even more docility than at present, the reveries of those who assumed to perform that duty for them; and were too often content with empty assertion and idle speculation, instead of requiring on the part of their teachers accurate reasoning founded on a close observation, and careful collation of facts. Their ideal creation—for it is nothing more—thus consecrated by time and general adoption, has taken so firm a hold on the popular mind, accords so well with vulgar prejudice, and cuts the Gordian knot of so many difficulties which perplex superficial inquirers, that it is, perhaps, vain to hope it will soon be abandoned. "We talk," says Dr. Adams, "of the extermination, extirpation, and eradication of a poison, till at last we reason upon it as if there were really roots which we were to destroy, and at least a certain quantity of some substance which we have the power of discharging from the system." Nothing is more common, even at the present day, than to hear of this blood-poisoning, and the consequent necessity of its elimination when

[1] Sir Henry Holland, in some interesting reflections on this subject, pertinently observes, in the true spirit of a philosopher, "We cannot trace diseases with certainty to this source, but how rare are the instances in which we can infer their real causes! The actual void of knowledge justifies our seeking them through all the new agencies which physical science may disclose, and none is more likely to afford successful results than that now before us."—See *Notes and Reflections.*

speaking of diseases—erysipelas, for example—in which nothing could possibly have been introduced from without; and yet, notwithstanding this universal agreement and reception, the hypothesis has no foundation in fact, is unsupported by anything like satisfactory, or even plausible argument, and is, in a word, a mere phantasy of the imagination, an intellectual *ignis fatuus*, which deludes us, indeed, with the semblance of knowledge, but enshrines no truth, and serves no purpose but to mystify and mislead.

The analogy between the nervous energy and electricity, first observed by Galvani, has been abundantly demonstrated by Dr. Wilson Philip, Magendie, and other physiologists, in their cruel, and often wanton, experiments on animals. The results, indeed, were so extraordinary as to induce in many minds the presumption of their actual identity; for nervous communication having been interrupted, it was found that the processes of digestion, respiration, and circulation were, for a time, performed as usual under the influence of electricity. Among its earliest discovered effects was the power of exciting muscular contraction in bodies recently dead. Later researches — those of Matteucci, Du Bois Raymond, and others—attest the presence of electricity in the most minute portions of muscular or nervous fibre, its evolution in currents during muscular contraction, and the different direction of those currents in relation to the longitudinal and transverse section of muscles. Its remedial agency, though still insusceptible of any very definite application to practice, has long been known; and with these and similar facts adapted to awaken curiosity and to direct inquiry, it is surprising that the possible pathological consequences which might reasonably have been expected to arise from its deficiency in the atmosphere, or its rapid abstraction from the system, have not been more generally suspected and investigated. Into the question of its identity with the nervous force, I have no present intention to enter. Nor is its affirmation or denial necessary to the establishment of my argument, which merely requires such a mutual relation or affinity, that the condition of the one shall be influenced by changes in the quantity or intensity of the other. Neither would I be understood as implying that there is not, over and above all this, a vital principle, the "breath of life," "breathed" into man at his creation, whereby he became "a living soul," a thinking, accountable, and immortal being. The human soul is unknown to us except as manifested through some organization of which it is the cause and not the result. It neither depends upon

matter, nor upon the organization of matter, but is a breath, a spirit, a ray of the DIVINE BEING, pure and immaterial; an emanation from His own Divine Nature, and consequently above all modes of matter—simple, indissoluble, indestructible, and eternal.[1]

All things—

> "Speak her nature
> Of subtler essence than the trodden clod,
> Active, aerial, towering, unconfined,
> Unfettered with her gross companion's fall."[2]

This is a subject, however, which, though deeply interesting, is too mysterious and recondite for human penetration; one of the "secret things" belonging to Him whose "judgments are unsearchable and His ways past finding out." I merely desire, *in limine*, to disclaim all alliance between the views here set forth and the gross heresy of materialism. Caloric, light, electricity, magnetism, and chemical affinity are all now thought to be modifications of the same element, and in view of the similarity of effect, it is no unwarrantable conclusion that under another modification that element may constitute the *vis nervosa* also. Between electricity and the imponderable, ethereal, mobile, and invisible quality which we call the nervous force, all physiologists admit that there exists a certain agreement and connection which involves reciprocal action. A remarkable proof of their close analogy, if not a strong presumption of their substantial sameness is afforded by the existence of several species of fishes furnished with an especial organization for electrical purposes, the action of which is dependent on the nervous centres; varies with the extent of that connection and the health of the animal; is under the control of the will; and is capable, when the fish is attacked or annoyed, of exhausting the nervous power by a continued series of discharges, to a degree sufficient, in some instances, to occasion its death.[3]

Mr. Milton, while he agrees with Müller in rejecting the idea that the nervous power is identical with electricity, thus expresses himself in regard to the relation which subsists between them:—

"Everything seems to point to the conclusion that there may be the same relation between electricity and the vital power as between

[1] Archdeacon Manning. [2] Young.

[3] The shock communicated by the *Gymnotus Electricus*, in countries where it attains a greater size than with us, is sufficiently strong to disable temporarily large animals, and even horses are with difficulty induced to enter rivers in which this fish abounds.—*Wild Scenes in Venezuela.* By Ramon Paez.

electricity and magnetism, or between heat and motion; that is, under certain circumstances, the one becomes the other. The frame is so charged with weak electricity, or with some force capable of being directly affected by electricity, that possibly every drop of serum may contain a certain portion, and the contact of two atoms highly charged with this force, one secreted by the male, and one by the female, may be productive of the same sort of change as ensues when the balance of electricity is restored by a thunder-storm, and result in the production of an atom filled with vital power, limited in its action and form by the nature of the parents which produce it; as distinct in its properties from the two atoms which formed it, as an atom of calomel is from one of chlorine or mercury, but, unlike the chemical atom, incapable of resolution into its primary constituents."[1]

What other rationale, it may be asked, can be given of the phenomena attending the act of generation, and of the nervous exhaustion which follows; so great, as in some of the insect tribes, to extinguish the ephemeral life of the parent, and even to prove fatal in man?[2]

The electrical fluid is the great agent in most of the operations of nature. In her inorganic domain it is the probable cause of all the chemical, and also of much of the mechanical change which we behold around us; for being the principle of cohesion in bodies, to its absence—synonymous with disintegration and decay—may be attributed, in part at least, what has been poetically described as "The Voice of Time," which

> "The Pilgrim oft
> At dead of night 'mid his orisons hears
> Aghast * * * * disparting towers."[3]

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[1] The Stream of Life on our Globe. By J. L. Milton, M. R. C. S.

[2] A case of this kind once came under the observation of the writer. The person had been married about a week. Indeed, instances of death from this cause have occurred both in man and the larger mammalia. Some physiologists believe that every organized being has a certain portion of irritability originally imparted to it, and that its life will be long or short as this is slowly or rapidly exhausted. If the coupling of insects be prevented either accidentally or purposely, it is possible to prolong the period of their existence, and at least to double it. In like manner, if an herbaceous plant, such as the mignonette, which dies down at the end of a year, have its flowers carefully cut away as soon as they appear, the plant, instead of becoming an *annual*, continues to live through the winter; and if the same operation be repeated throughout the following year, our mignonette will soon become a *ligneous* vegetable—a real tree; and from that moment the duration of its life is unlimited.—Phipson. *Utilization of Minute Life.*

[3] Dyer's Ruins of Rome.

The electrical condition of the surface of the earth is undergoing incessant fluctuation, owing partly to differences of temperature, the radiation of heat, etc. etc.; and as M. Becquerel has shown that electricity, positive or negative, is developed whenever the molecules of bodies are deranged from their natural position, the chemical changes thus induced must be a fruitful source of variation in the electrical strata of the atmosphere. Modern science has demonstrated that a vast electrical belt encircles the globe, giving polarity to the magnetic needle; and, as a fluid so ethereal and unstable cannot be inactive or inoperative, is necessarily concerned in the production of many phenomena now unknown and unsuspected. Since, moreover, its four points of greatest magnetic intensity are constantly changing their position, those in the north going from west to east, and those in the south from east to west, the whole magnetic system of the earth is also in perpetual oscillation. According to Mr. Fox, even the direction of the metallic veins has been influenced by the direction of the magnetic meridians; for it has been observed that almost all the metallic deposits in the world tend from east to west, or from northeast to southwest. It has hence been inferred that "magnetic currents may have influenced, and still influence, the direction of life, food, soil, water, and the distribution of plants and animals."[1]

In the vegetable kingdom electricity performs, if possible, still more important functions; not only producing, in conjunction with its analogous agencies of light and heat, conditions favorable to the germination and growth of plants, but quickening them into life, and thus becoming the efficient instrument of their development and of the productions which they severally yield. Its intense and rapid passage, as in the lightning stroke, immediately kills the largest tree; and a very slight shock sent through certain plants will, we are told, speedily cause their leaves to droop, and as certainly, though more slowly, extinguish their vitality. The approach of an electrified conductor to the Mimosa Pudica, or Sensitive Plant, produces no apparent effect, but if sparks be taken from it, the leaflets will shrink and close, as they do from mechanical contact. Its more steady and quiet operation on vegetable life is equally remarkable. An electrical circle has been formed by wires running under the beds of a garden, and the result is said to have been greater vigor and rapidity of growth in the plants which they

[1] Milton.

contained. It evidently performs the part of a general stimulant, which, when in moderate quantity, as it usually exists in the atmosphere, is not only salutary in its effect upon vegetable life, but actually necessary to its healthful condition. The disease which lately attacked the potato, and produced such great distress among those who depended largely for their food upon that esculent, has been attributed, with much probability, to its deficiency.

A principle so influential in its action upon vegetable life, so subtle, so fluctuating, and so universally diffused, might *à priori*, have been supposed capable of exerting a very important influence also over the higher organization of the animal economy. Its presence, in a certain degree, might not irrationally have been presumed necessary for the continuance of life, and the healthy performance of all the functions. The conducting power of the nerves had been proved by the physiological experiments just alluded to; and their anatomical organization, demonstrating that they are tracts of medullary matter, affords convincing proof that while they reinforce or intensify the impressions which they receive, and by the nervous power which they also elaborate, preside, to some extent independently, over the capillary circulation, and the processes of absorption, digestion, etc., this conduction is, in reality, one principal office which they discharge. Indeed all the circumstances of structure, arrangement, and action would naturally lead us to regard the brain and the whole nervous system as an organized apparatus, through the medium of which electricity, modified and restrained by certain laws, is made subservient to the purposes of existence; in other words, as a vital electrical or galvanic machine, by means of which that element, developed in the processes of respiration, digestion, and assimilation, is appropriated and distributed in accordance with the wants of animal life. What we should thus have supposed probable, is found to be true in fact; electricity when present in excess exciting the functions and exalting vitality, while a contrary effect is produced by its subtraction or deficiency. In a state of health and mature existence, when all the functions are vigorously performed, and the power of resisting noxious agencies is greatest, the disturbing influence of such fluctuations is slight; but under other circumstances they become a frequent and potential cause of disease. We have all experienced the feeling of energy and elasticity which is imparted by what is termed bracing weather, when the air is dry and cold; and can recall more strongly still, because of its unpleasantness, the sensations of chilliness and

discomfort when the atmosphere, loaded with moisture, has become an active conducting medium, and its injurious operation is further increased by the agency of cold; which, under such circumstances, has a depressing, instead of a stimulating, or an invigorating effect. The nervous system of some susceptible individuals is readily thrown into commotion by an approaching thunder-storm. I have one patient, for many years the victim of an annual catarrh, whose sufferings are always greatly aggravated by the occurrence of thunder and lightning at any time during the paroxysm; and have recently attended another—a singularly intractable case of retinitis occurring in a strumous constitution—in which relapse was almost sure to follow under such circumstances. Rheumatic, neuralgic, and paralytic persons, and those who have lately suffered from sprained or fractured limbs, can predict with unerring certainty an impending atmospherical change;[1] and the evening exacerbations which we observe in fevers are partly owing to the same cause; the system in its disturbed and debilitated condition being unable to bear, without suffering, electrical changes which would have little or no perceptible influence in a state of health. The pain of rheumatism, neuralgia, and the uncomfortable sensations accompanying catarrh, are in like manner, and partly for the same reason, all aggravated at the approach of evening,—something being no doubt attributable also to nervous exhaustion through the excitements of the day.

The following observations of Professor Laycock, of Edinburgh, evince a near approximation to the true theory on this subject; and accord also with the remark of Sir Henry Halford, that if he ventured to name any particular periods in the twenty-four hours at which changes most obviously take place both in health and disease, he should fix upon the hour of two or three in the afternoon, and the corresponding time in the night:—

"In the first place we find that the atmospheric tides attain their maximum and minimum at certain hours of the day; for there are

[1] It is worthy of remark that these effects are chiefly produced in the meteorological changes which precede a storm; when the rain or snow actually begins to fall, the electrical equilibrium is restored, and if the vascular system has not become involved, neuralgic pains and uncomfortable sensations subside. The effect of a thunder-storm in inducing acidity and coagulation of milk is familiar to every one; meat in like manner has been observed to become sooner tainted; and it has been observed to influence also the incubation of eggs, at least when hat process is attempted by artificial heat.

tides in the circumambient atmosphere, as well as in the circumambient ocean; and therewith there are also changes in the electricity of the air, and the magnetism of the earth. From 8 to 10 A. M. and P. M. the barometer is at its maximum height; the electric tension is at its maximum too; and there is also the greatest maximum variation east of the magnetic needle at the same hours. From 4 to 5 o'clock A. M. and P. M. the barometer is at its minimum, and so is also the electric tension. The respiratory movements, and, of course, the activity of the circulation are likewise in connection with these hours. About 4 or 5 o'clock in the morning, with a minimum temperature, a minimum electric tension, and a minimum height of the barometer, there is also a minimum consumption of oxygen. Farther, I have ascertained by frequent inquiry, that sleep generally comes on about that hour after a feverish and restless night; and, what is more remarkable, the statistics of death in York show that the chances are in the proportion of 3 to 2 that the last sleep—the sleep of death—will occur at that hour."[1]

It is these changes, moreover, consequent upon the withdrawal of the sun's rays, by which the dew is precipitated, and the conducting property of the air thereby increased, which render exposure at this time so dangerous in certain districts of country—as in the Maremna and Campagna, where the surface of the earth, owing to internal causes, may also be negatively electrical, and in the so-called malarious localities generally—and not, as is commonly supposed, the greater prevalence on such occasions of miasmatic exhalations. At a later period of the evening, when the dew has actually fallen, the atmosphere, being drier, is less penetrating, and exposure consequently is somewhat less injurious. The early morning air, though charged with the ascending dew, is less deleterious, because, among other reasons—its greater density, etc., whereby more oxygen is breathed—it acts upon a body in some measure invigorated and refreshed by sleep; but its influence, in debilitated states of the system more particularly, is nevertheless prejudicial; and hence the recommendation to fortify the stomach by a previous meal, the prescription of "bitters," quinia, etc., which act by imparting temporary energy to the frame. The extreme sensibility to electrical fluctuations of the affections which are purely nervous, is a subject of common observation. Every

[1] London Medical Gazette, vol. 38.

physician must have noticed the greater frequency of attacks of nervous asthma, in persons subject to that complaint, before a change of weather. The epileptic paroxysm occurs most frequently in the night, and though this may, perhaps, be explained in part by the temporary suspension of the will in sleep, it is not unreasonable to attribute it, in some degree, to the electrical changes which take place at that period; especially as we know that some persons subject to this malady are only affected at the vernal and autumnal equinoxes, when those changes are greater than at other times. Rheumatism and neuralgia hardly excepted, there is not a disease in the whole catalogue, the phenomena of which are more obviously in harmony with the electrical theory than those of idiopathic epilepsy. The periodical accumulation of excitability and its exhaustion by the paroxysm forcibly recall the circumstances attending the experiment of the Leyden jar.

The familiar expression of "taking cold," which is supposed to account so satisfactorily for many of the ills to which flesh is heir, may be mentioned as another example of such influence. This is commonly owing, not to variations of temperature, as is generally believed, but to disturbances of the electrical equilibrium, of which those variations are the effects or accompaniments. It is not unusual for individuals, especially those of tender age, to retire in apparent health to rest, in a comfortable room and bed, and to awaken after some hours with a sore throat, or a paroxysm of croup; and we have all known persons to be attacked with these and other complaints said to arise from "cold," who have been closely confined for days or weeks to apartments, the air of which has been steadily maintained at an elevated temperature. They could only have been affected, therefore, by changes in the electrical condition of the atmosphere without, and these would be felt with the instantaneousness of thought, however the individual might be situated and protected.

The rationale is substantially the same when indisposition is induced by sleeping on the damp ground, exposure to a draft of air, too long continuance in a cold bath, sitting in wet clothes, etc.; under such circumstances the system parts with its vital electricity more rapidly than it can be generated without disturbance, and the popular phrase is sufficiently expressive of what has occurred.

"When we take into consideration," says Mr. Craig, "the principles here advocated, viz: that electricity and nervous force are identical, that the electricity evolved from the air in the lungs, and

that separated from the ingesta during assimilation, is that which supplies the vital electricity to the nervous system, and that any cause which hinders the supply, or suddenly, and to a great extent, withdraws it after being supplied—there is here an appreciable combination of causes which will injuriously affect the system: taking cold will thus be an easily comprehensible idea. The escape of heat—that is, the withdrawing of electricity from the body—is understood to be taking cold. The abstraction of vital electricity from a person whose nervous system has nothing to spare, will cause derangements that will be developed in some form of disease; the nervous currents in such circumstances, acting on a secreting gland, may be insufficient to elaborate from the blood those constituents which are required to form the various secretions; and in this manner may the secretion be imperfectly eliminated, and the depuration of the blood incompletely effected; and the retention of those elements which ought to have been given off will give rise to diseases which result from the vitiation of the fluids of the body."[1]

The effect on the gravid female of certain atmospheric conditions has long been observed. "Cold, rainy weather, and low, damp miasmatic localities," says Professor Gilman, "have been recognized since the days of Hippocrates as disturbing pregnancy and causing abortion. To the influence of the atmosphere is to be attributed the frequency of abortion, or other mishap in pregnancy by which some years are signalized."[2] The probable explanation is, that the expenditure of the nervous energy, in the reproductive process, renders the system more liable to be affected by electrical changes, the influence of which is increased by the greater conducting power of the atmosphere in the places and seasons mentioned. Insane persons, on the other hand, have always been observed to be in a remarkable degree insensible to atmospherical vicissitudes, as well as free from epidemical influences; and this exemption is, no doubt, due to the habitual exaltation of cerebral action in their case.

"Beyond all doubt, electric disturbances in the atmosphere produce visibly what are often the forerunners of disorder. On the 8th of May, 1831, the air in the neighborhood of Algiers was so

[1] On the Influence of Variations of Electric Tension as a Cause of Disease. By William Craig, Esq., Surgeon, Ayr.

[2] Notes to the American edition of the Dublin Practice of Midwifery.

full of electricity that it appeared to be on fire. Luminous points issued from the ends of the hair and the tips of the fingers of the officers. All those exposed to this air suffered from spasms in their limbs, and weariness. Any considerable fall in the barometer, which is accompanied by a change in the electricity, produces in many persons a lassitude, followed by restless or uneasy sleep, or frequent and laborious breathing. Sir Henry Holland remarks that the mere dryness of east winds will not explain the aching and languor they produce, and expresses his opinion that the sirocco is a current of negative electricity. Dr. Ure, in a paper read before the Royal Society, stated that the effects of negative electricity in the air, as observed in the long room of the Custom House, were vertigo, fulness and tension about the head, quick and feeble pulse, and defective circulation in the legs and feet."[1]

These, and a host of similar facts, may be adduced to prove that there is nothing improbable in the hypothesis that, under circumstances of predisposing or concomitant influence, general in their operation, or affecting individuals only, pathological consequences of far greater gravity, variety, and extent, may be produced from the exhaustion of nervous energy by the subtraction of vital electricity from the system, through changes in the external distribution of that fluid; especially when those changes, owing to operations on the surface, or in the interior of our planet, are of greater magnitude and longer continuance than usual; and that the impaired innervation thus induced may be the proximate cause, not only of the exanthemata and most other forms of fever, congestive and otherwise, but also of cholera, diphtheria, influenza, hooping-cough, erysipelas, dysentery, the idiopathic phlegmasiæ, etc. etc. Among the circumstances alluded to as affecting individuals, and thus giving efficiency to electrical fluctuations, may be enumerated fatigue, fasting, loss of sleep, hemorrhages, the depressing passions, the exhaustion produced by long-continued heat, the prevalence of moist weather, warm or cold, atmospherical changes, and whatever tends to debilitate the system and exhaust or diminish nervous power.

To my mind the conclusion is irresistible, that an element which pervades all nature, and sustains so important a part in all her operations; which is so analogous to the nervous force that it may be substituted for it in the performance of its appropriate func-

[1] Milton.

tions; which, when in usual quantity, maintains the organism in healthy action, and stimulates or destroys, according to the degree of its excess; must, by its deficiency or subtraction—especially in debilitated states of the system, and when aided by any cause tending of itself to depress cerebral action—exert a far more potential influence for evil.

The long continuance, in various degrees and combinations, of heat, cold, dryness, and humidity, or the marked predominance of any one of these conditions, will determine the character of the prevailing diseases. A hot and dry summer, for instance, will be nosologically distinguished by affections of the alimentary canal. A higher grade and longer continuance of heat, producing a greater degree of exhaustion, and occasioning by its reflex action a strong tendency to inflammation of the stomach, liver, and their associated organs, is the predisposing cause of yellow fever. In the early autumnal months, the stimulus of light and caloric being lessened, while the system, exhausted by the previous heat, remains weak and impressible, and therefore easily affected by electrical changes —the influence of which is promoted by various meteorological circumstances, as cold, humidity, etc.—intermittent and remittent fevers, in which the pathological condition is rather congestive than otherwise, chiefly abound. The cerebral functions are impaired, the several processes by which nervous force or vital electricity is supplied, are either suspended or less efficiently performed; innervation is lessened, vascular congestion takes place, and, reaction following, the usual febrile phenomena are developed; which assume an intermittent, continued, or adynamic form, according to the intensity of the cause and the degree of the pre-existing debility. A peculiarly raw and penetrating condition of the atmosphere precedes and accompanies influenza, a disease which ordinarily attacks persons of feeble power, and is characterized by excessive nervous disturbance and prostration; while an open, wet, and variable state of the weather, such as we frequently have at the approach of winter, is favorable to the production of the exanthemata, typhoid fever, erysipelas, etc. The reaction occasioned by a higher degree of cold—the air being dry, and having, therefore, little or no conducting power—is salutary and invigorating.

The manner in which this state of negative electricity is induced is very clearly set forth in the following remarks by Mr. Craig:—

"Foremost among the agencies which abstract caloric or electricity from the animal body may be placed that universally

diffused element—water. More especially does it operate thus when it is being changed into vapor. When water is assuming the form of vapor it absorbs an immense quantity, and it is during this process that portions of the earth, and the objects on it, are, for the time being, deprived of a large amount of electricity. Now it is on the principle that evaporation withdraws from the animal economy the electricity which is evolved during the vital operations of digestion, respiration, etc., that injurious influences are exerted so generally, especially on the predisposed, as are sufficient to cause epidemic and wide-spread disease. In tropical countries the rain falls in much larger quantities than in countries of a higher latitude, and it has all to be raised again by the process of evaporation; it is the solar heat radiated from the earth, and from those bodies which are placed on it, that provides the heat to raise the vapor. It is when this evaporating process is going on that electricity is carried up; while the earth, with the objects on it, is to a certain extent deprived of electricity.

"So constantly is humidity associated with the existence of endemic and epidemic disease, that it may be stated, as a general rule, that in proportion to the amount and rapidity of evaporation in any given situation, so will be the extent and virulence of pestilential disease. In all speculations on this hitherto dark subject, whatever has been conceived to be the cause of epidemic disease, it is always supposed that humidity contributes to its virulence, and is indispensable for its full development. Hence it is found that diseases are most prevalent in situations where water is most easily and most copiously generated—in valleys, on the banks of rivers, near shallow marshes, in the vicinity of mangrove plants, and wherever a favorable condition of the surface exists to accelerate the process of evaporation. The rainy season, or rather immediately after it, is well known to be the most sickly in tropical climates."

In estimating the influence of this deficiency in the quantity of electricity in the atmosphere, sufficient weight, I repeat, is not generally given to the circumstances which favor its operation; or, in other words, to the predisposing causes. These may be briefly stated to be thermometrical and hygrometrical conditions on the one hand, and, on the other, whatever tends to enfeeble and exhaust the vital power. The air which, when dry, is an excellent non-conductor, becomes, when charged with moisture, an actively conducting medium; and in this state of things the nervous energy is abstracted from the body more rapidly than it can be generated

without cerebral commotion and disorder; the innervation is consequently lessened; the vessels of some organ or tissue predisposed to disease, lose their tone, and, becoming dilated, admit the red globules of blood; congestion ensues, followed by reaction as an instinctive effort to repair the mischief which has been inflicted; inflammation is set up; and various morbid aberrations are the result. The intense heat of our summers, by the over-stimulation which it induces—and which by its reflex action is in itself a frequent cause of disease—is always enervating and exhausting. This may not be immediately felt so long as the stimulus continues to be supplied, but when this is withdrawn or greatly abated, before invigoration takes place under the reaction from the cold of a later period, the system, obeying the natural law which governs the discontinuance of an accustomed stimulus, falls into a state of depression corresponding to the previous elevation, and becomes a ready prey to the atmospherical changes just alluded to.

It is to variations in the quantity of electricity usually present in the atmosphere, produced by operations on the surface of the globe or within its interior, and from their proximity to the surface, or the conducting capacity of the soil, affecting some localities more than others, acting upon constitutions thus impaired, that the different epidemics which have desolated the earth are, in my opinion, to be attributed.

It is a matter of common observation that our winters occur in cycles of cold and of mild weather of indefinite continuance; and that the latter are marked by the prevalence of diseases of an adynamic type. Through one of these we appear to be now passing; and the remark is frequently made that, since the visitation of the cholera more particularly, depletory measures are not so well borne as formerly. Such being the case, it may easily be conceived that under strong predisposing and exciting influences the brain, acting in particular individuals with less than ordinary vigor, and hence endowed with less capacity of resistance to morbific agencies, may be suddenly discharged of its nervous energy, without any appreciable lesion being discoverable after death. Instances of this kind are said to have occurred during the late epidemic of "spotted fever"—especially among children, who, owing to their immature or unconfirmed viability and the greater proportional development of their nervous system, were most frequently its victims—in which the whole course of the malady occupied only a very few hours. The vital power was ruthlessly assaulted in its very citadel; the brain

and spinal marrow, unable to throw off the morbid impression upon other parts, owing to the prevailing asthenia, become themselves the seat of disease; and when the attack was less suddenly fatal, congestion of that organ ensued, followed by all the symptoms of nervous oppression and disturbance; terminating in a few cases in resolution and recovery, but far more commonly in cerebro-spinal meningitis and—death.

But it is not always, nor, happily for mankind, often indeed, that the morbid movement which originates in the brain, expends itself upon that organ. This takes place only under the existence of strong asthenic tendencies. It seems to have received such a direction in the "spotted fever" which prevailed in New England during the early part of this century. In the Middle States, owing to some climatic changes, the determination was to the lungs, and the malady assumed the guise of typhoid pneumonia; while in the western part of our country, then almost in its primeval condition, it was known as the "Cold Plague," from the severity of the rigor caused by the congestion of the portal circle. Here, then, we have the same cause acting upon predispositions engendered by circumstances modifying its operation, producing apparently very different results. Instances occurred in some localities during the late epidemic also, in which the chill was the most prominent symptom, evincing thus less implication of the brain and greater congestion of other organs.[1]

The epidemic cholera furnishes another and apposite illustration of the manner in which disease is produced by great exhaustion, or abstraction of the nervous power. Under the operation of its exciting cause—which, as will be presently shown, has been almost demonstrated to be deficient electricity—the innervation is greatly lessened or suspended; but owing to some predisposing influences affecting the nerves of organic life, the determination is chiefly to the mucous membrane of the intestinal canal; the capillaries of which lose their tone, and permit the serous portion of the blood to flow unrestrained through their myriad apertures.[2]

[1] This feature, as stated in the daily papers, was especially observable in some parts of New Jersey, as in the neighborhood of Long Branch.

[2] This disease, also, or one that is essentially the same, sometimes prevails epidemically under a more simply congestive form, as in that singular modification called in Persia, Tab i Ghash, or "Fainting Fever," which is described by Dr. Bell as "an ague which never comes out;" and for which he recommends bleeding in the cold stage as the chief and almost only reliable remedy. It appears to have

The view which I have taken of this subject is not, as I have already intimated, wholly speculative. The diminution of magnetic power during the prevalence of cholera has been ascertained by direct experiment. Mr. Mather, of South Shields, England, states that in 1849, when cholera of a very fatal character was epidemic in his neighborhood, he found, as the result of numerous observations carefully made, that a magnet which ordinarily carried two pounds and ten ounces, would, when the atmospheric indications were nearly at their worst—the air being saturated with moisture—sustain only one pound and ten ounces; the degree of its attraction varying with, and being in inverse proportion to, the violence of the disease.

The same year the number of deaths in Paris from this pestilence rapidly increased until the 8th of June, when they amounted to six hundred and twenty-three. On the evening of that day there occurred a thunder-storm of unusual severity, and the cholera immediately began to decrease; by the 18th of the month there was a daily report of one hundred only; and at its close the mortality had fallen to thirty.

Mr. Craig, to whose essay on the Influence of the Variations of Electric Tension as a Cause of Disease, I have above referred, and whose remarkable agreement in opinion and argument with the views here set forth—abundantly fulfilling the Scriptural requirement of two witnesses—goes far to establish their truth, refers in fuller detail to the observations of M. Andrand, made at the same time and place; and also to similar experiments performed at Glasgow. In a communication to the French Academy, dated July 10th, after stating that his machine was very powerful, that gentleman continues: "I have remarked that since the invasion of the cholera I have not been able to produce on any occasion the same effect. Before its occurrence, in ordinary weather, after two or three turns of the wheel, brilliant sparks of five or six centimetres in length were given out. During the months of April and

had many features in common with our "Cold Plague," an algid form of congestive disease, in which, as I have been informed by my relative, the late Dr. Littell, of Ohio, he found an emeto-cathartic—the sulphate of magnesia with the tartrate of antimony—the most successful treatment. Sporadic cases of this kind, unattended with any disturbance of the alimentary canal, or any of the other symptoms which usually characterize the disease, were not infrequent on the first invasion of the cholera in this country, and were among the most intractable examples of the malady.—*Eastwick's Journal of a Diplomate's Residence in Persia.* Vol. ii. p. 329.

May, the sparks, which were obtained with great difficulty, have never exceeded two or three centimetres, and their variations accorded very nearly with the variations of the cholera. This was already for me a strong presumption that I was upon the trace of an important fact I was endeavoring to find. Nevertheless, I was not convinced, because one might attribute the fact to the moisture that was in the air, or to the irregularities of the electrical machine. Thus I waited with patience the arrival of fair weather, and to my astonishment the machine, frequently consulted, far from showing, as it ought to have done, an augmentation of electricity, has given signs less and less sensible; to such a degree that, during the days of the 4th, 5th, and 6th of June, it was impossible to obtain any thing but slight cracklings without sparks. On the 7th of June the machine remained quite dumb. This new decrease of the electric fluid has perfectly accorded with the renewed violence of the cholera, as is only too well known. For my own part, I was more alarmed than astonished; my conviction was complete. At last, on the morning of the 8th, some feeble sparks reappeared, and from that hour the intensity decreased. Towards evening a storm announced at Paris that the electricity had re-entered its domain; to my eyes it was the cholera which disappeared with the cause that produced it. The next day I continued my observations; the machine at the least touch rendered with facility some lively sparks; and in the five days following, the mortality in Paris fell gradually from 667 to 335."

"A gentleman in Glasgow, during the prevalence of cholera in that city in 1849, informed me," says Mr. Craig, "that he had an excellent electrical machine, which at all times yielded large sparks of electricity with the utmost facility. He was very much in the habit of using it, and was well acquainted with the science. He stated that at the time above specified, when cholera prevailed, he had the utmost difficulty in producing the slightest sparks, notwithstanding the rubbing, and heating, and brisk turning of the machine. As it was no part of this gentleman's object to trace any relation between this low tension of terrestrial electricity and the cause of cholera, he took no notes nor dates as to the time when the peculiarity began and when it went off.

"From the observations of these two gentlemen, it is evident that there was a connection between the low state of terrestrial electricity and the existence of cholera. In the one case the evidence was quite unconnected with any idea of theory, and in the

other case there were no definite notions entertained by M. Andrand regarding the nature of the connection between cholera and the diminished tension of electricity. He evidently connects the cause of cholera with the amount of electricity existing in the air, as he remarks that 'he felt with joy that the vivifying fluid was returning to the atmosphere.'

"I consider that these facts are very conclusive in support of the theory here advocated. They distinctly indicate that the electric condition of the mineral strata and superincumbent mineral debris on which Paris and Glasgow rest, were at the period when cholera raged, in a negative or low state of electric tension."

Besides the causes concerned in producing electrical changes on the exterior of the globe, it is very probable that the electrical condition of the surface, and consequently of the objects connected therewith, may be affected also by operations going on in its interior; and the prevalence of cholera in Sicily, Madeira, and Central America—all of them volcanic countries—gives some plausibility to the conjecture. A state of igneous fusion is believed by many to exist within our planet, and, if such be the case, electricity must necessarily perform a prominent part in that mysterious portion of nature's great laboratory. It tends, as is well known, to seek the periphery, rather than the centre of bodies, and more will therefore obviously depend upon the activity of the conducting power, than the mere thickness of the intervening strata; thus furnishing a solution to the question, why some districts suffer severely from such visitations, while others enjoy absolute or comparative immunity. The air of the Pontine marshes near Rome, so fatal to those within its influence, is said to be very deficient in electricity, and probably from the same cause. It may, however, be remarked, in passing, that the air of marshes, and of still-water generally, is more prejudicial than that of rivers, or running streams; partly for the reason, that the air saturated with moisture, undisturbed by atmospherical currents, and possessing therefore a more actively conducting property, lingers upon them in unbroken mass long impervious to the rays of the sun; and partly because, in the latter case, the motion of the particles among themselves, and their friction against the hills, trees, etc., are developing causes of atmospherical electricity. It is probable in both of these ways that the agitation of the air, by the frequent passage of a steamer—itself a powerful hydro-electric machine—increases the salubrity of places in its vicinity, or restores it when lost; as—

to mention a fact familiarly known—has been the case with the Schuylkill above the dam at Fairmount.[1]

I have dwelt the longer upon this subject in its connection with cholera, because if the argument be deemed conclusive in respect to that disease—and I do not see how its force can be evaded—it will create a strong presumption of the similar causation of other epidemical complaints; the procession in all cases being the same, though the effect, which is determined by local circumstances, may be as various as the tissues and organs acted upon; thus demonstrating, among other things, so far at least as its etiology is concerned, the essential unity of disease.

While minute and laborious attention has been bestowed on the thermometrical state of the atmosphere, its density, humidity, dryness, the direction of the winds, etc. etc., few observations have been made, and still fewer recorded, of its electrical condition in relation to morbid action. That the subject, however, is beginning to engage the thoughts of physicians, is evident from the following interesting, but unhappily imperfect remarks, which I copy from the work of Mr. Milton already quoted on several occasions:—

"One important point would be to find out if there is any connection between disturbance in the electricity of the air, and disorder of the health, what this connection is, and to what laws it is subject. In order to see if I could obtain any evidence as to this question, I selected a very common form of inflammation. As it is very painful, patients generally apply soon for relief. A tolerably long period was chosen, so that the results might not be vitiated by any hasty conclusions. Three large hospitals were visited, and the books, on being searched, gave for the year 1852 three hundred cases, and for the year 1853 five hundred and nine. In the first year there was a slight but steady rise up to the end of the third quarter of the year, when the proportion increased so rapidly that in October there were nearly twice as many cases as in the highest of the preceding months, and then the number again declined till the end of the year. The smallest number of cases occurred in June, July, April, and January.

"In the year following, 1853, the greatest number of cases which

[1] At the time of the cholera which prevailed at Columbia, Pennsylvania, in the summer of 1854, the wind blew during several days in a particular direction, wafting over the town the air of a marsh saturated with moisture, and impregnated with animal effluvia. This disease everywhere evinces a preference for the great water courses of a country.

occurred in any one month took place in July, when there were sixty; a striking contrast to the same month in the year preceding, when there were only five; confirming a view I long ago stated, that mere heat and cold have in themselves very little to do with disorder of the health. Next to July in this year, stand December and October, which yield respectively forty-six and fifty-two. The lowest number is met with in March, May, June, and August of this year, which give an average of less than thirty-two; while January, April, and November show nearly half as many more.

"Now, when examining the tables of the heat, wind, etc., during these periods, I could find no changes which at all tallied with the variations in the number of cases of disorder; but, on turning to the electrical column of the meteorological report, some changes were noticed which seem to coincide with those in the amount of disorder. For instance, during the first eight months of 1852, there was an exceedingly small number of cases; now, during the greater part of this time, the number of days on which negative electricity was registered is very small indeed. Week after week the electricity is reported as positive with moderate tension. In the second week in September the number of cases is greater than had been noted for a long time; and now the electricity is reported negative and very active. Immediately after this there is a fall in the number, and the electricity is again marked positive and active. Then, after a slight wavering, a great increase in the number of cases is found for many weeks after; and from this time till Christmas, the reports give 'no electricity at all.'" At this juncture, unfortunately, the clue of the investigation was lost, the electrical apparatus having been damaged in a gale of wind, and a long time elapsed before it could be put into working order.[1]

The meteorological condition of the atmosphere in which influenza prevails would incline us to assert with confidence the origin of that complaint in deficient, or negative electricity; and most of the diseases to which I have before alluded are notoriously most frequent in seasons of the year when electrical currents and changes are greatest, and their injurious operation aggravated by moisture and other auxiliary influences. Chief among those in regard to whose nature and causation there is the nearest approach to una-

[1] Mr. Milton does not mention the form of inflammation which he selected as the subject of his investigation; and the electrical changes noted were, probably, such as occur in ordinary states of the atmosphere, when there is no epidemic prevalence.

nimity of opinion, are the several varieties of autumnal fever. They are almost universally attributed to the agency of marsh miasmata; but, notwithstanding this general agreement, there are many facts utterly irreconcilable with that hypothesis. And even admitting that these supposed exhalations—for of their actual existence we have no proof—are not altogether innocuous, I am fully convinced that they are not an ordinary source of disease, and *never* of those under present consideration. The complaints supposed to be thus engendered, prevail in seasons when electrical vicissitudes are greatest, and the body, debilitated and otherwise disordered by the protracted heat of summer, is most sensible to their impression; they are often observed where there is no reason to suspect the operation of miasmata; where, in fact, miasmata and the circumstances which give rise to it do not exist; are evidently reproduced by other causes after they have once occurred; and are promptly cured by means which eliminate no poison, but merely restore the lost tone of the system—frequently indeed by mental impressions alone.[1]

Were it true that intermittent and remittent fevers owe their origin to paludal exhalations, or to miasmata however generated, we should naturally expect to find them most prevalent when vegetable decomposition is greatest, but a moment's consideration will show the reverse of this is true. In the Middle and Western States, and perhaps throughout our country, September is the sickliest of the autumnal months; and yet vegetable life still flourishes, often in almost undiminished vigor; the foliage preserves its freshness and verdure, and nature exhibits few symptoms of approaching decay. The days, moreover, have become considerably shorter, the weather cooler, and it is evident, therefore, not only that matter for decomposition is not supplied in greater abundance, but that the circumstances which concur in that process are really less active than they were in the preceding months. Those seasons, also, which are characterized by an unusually late fall—vegetation being fostered by timely rains, and long unchecked

[1] The *modus operandi* of quinia ceases on these principles to be any longer a mystery; or rather it involves no greater difficulty than that of all other remedial agencies. Its action is simply tonic, or restorative of nervous energy; whether administered in large doses, as an anti-periodic—anticipating exhaustion and promptly exalting cerebral power—or, in smaller and oft-repeated portions with a view to the production of its less sensible and more sustained operation. The same remark applies also to opium, etc.

by frost—are precisely those in which autumnal fevers prevail more extensively, though, owing to the system being less exhausted by heat, of a milder type than under other circumstances. When such conditions exist, they are found not only in localities where we should expect to meet with them, but also on elevated grounds, and often in the very heart of our cities. Facts like these cannot be accounted for on the theory of miasmatic exhalation, but receive a ready explanation from the known agency of humidity in increasing the conducting power of the atmosphere, and thus giving greater effect to electrical changes.

That intermittent and remittent fevers prevail epidemically in the autumn, and occur only in sporadic cases during the spring, is owing to the circumstance that, in the former case, the system, unduly stimulated by the heat of summer, and left in a state of exhaustion and debility by its withdrawal, is less able to resist the electrical currents and fluctuations which are the efficient cause of their production. Seasons in which the warm weather has been unusually protracted, and the winter uncommonly mild, are those in which the most desolating epidemics have occurred; for this reason, among others, that the system uninvigorated by the reaction produced by cold, falls a ready prey to the operation of the cause which I have suggested—acting, it may be, on a grander scale, from fuller development on the surface, or from processes going on in the interior of the globe. In some equatorial climates —that of Guayaquil, for example, where earthquakes are frequent— this is the invariable state of things. The winter is the period of almost incessant rain for five or six months' duration, and the mortality during the ensuing comparatively dry season, when evaporation is most active, and internal terrestrial commotion most common, is consequently very great.

The human frame possesses a great power of accommodation to external agencies, especially when these are uniform and constant in their action. The air of the sea, and, generally, of places in its vicinity, though saturated with moisture, is healthy for this reason; for the moisture being universal and invariable, tends to maintain the electrical equilibrium, though perhaps at a lower range; while the system being less enfeebled and disordered by heat, the atmosphere cooler and more refreshing, such fluctuations as do occur are less sensibly felt. Hence also it is that, in a very rainy season, localities which have been the immemorial haunts of fever, become

comparatively healthy; while upland districts rarely visited by it suffer in their turn.

A remarkable illustration of the manner in which fever was developed on a large scale by the sudden abstraction of vital electricity from the system, is recorded by Mr. Eastwick in his Journal of a Diplomate's Residence in Persia; the cause being very correctly stated by his informant, a lieutenant of engineers. "He told me that Suram"—a village of Georgia—"was very unhealthy, and that the year before, out of three thousand soldiers employed on the road, one thousand were constantly ill with fever. He said the sickness was owing to there being always a cold wind, and a bright intensely hot sun. The men threw off their clothes, and were immediately struck down with fever."[1]

A striking instance of a country in which every circumstance of climate, soil, and atmosphere might be supposed to unite in the production on a grand scale of paludal exhalation, is mentioned by Dr. Hooker in his Himalayan Journals.[2] The delta of the Soormah extends for a distance of eighty miles along the old bed of the Burrampooter, a river five miles broad, and forms an immense still and narrow sheet of deep, clear water, called the Jheels. The area drained by the Soormah is scarcely raised above the level of the sea, and contains about ten thousand square miles. In the dry season the Jheels are marshy, but during the rains, which are excessive on the neighboring mountains, they are entirely overflowed, the water rising to within a few inches of the huts which are built along the borders of the rivers which traverse it. The soil, sandy along the Burrampooter, is more muddy and clayey in the centre of the Jheels, with immense accumulations of vegetable matter in the marshes, consisting chiefly of decomposed grass-roots and leaves. "The climate of Chaltuc," says the doctor, speaking of one of the villages, "is exceedingly damp and hot throughout the year, but though sunk amid interminable swamps, the place is perfectly healthy. Such, indeed, is the character of the climate throughout the Jheels, where fever and ague are rare; and though no situations can appear more malarious than Silpat and Cachar, they are in fact eminently salu-

[1] Vol. i. p. 83. The momentary shudder which is sometimes felt on going into the sunshine in warm weather is caused by the escape, or radiation of vital electricity, owing to its affinity with the solar heat; and relapses in intermittent fever are often attributed, by the people of the country, to imprudent exposure to the rays of the sun.

[2] Vol. ii. p. 263.

brious. These facts," he continues, "admit of no explanation in the present state of our knowledge of endemic diseases. Much may be attributed to the great amount and purity of the water, the equability of the climate, the absence of forests, and of sudden changes from wet to dry; but such facts afford no satisfactory explanation." Undoubtedly they do not, on the supposition that malaria is necessarily concerned in the production of these complaints; but discard that hypothesis and they receive an obvious elucidation on the theory of their electrical origin. Humidity alone, when universal and constant tends, as I have said, to preserve the electrical equilibrium, and the great extent of their surface gives to the Jheels the character of an inland sea; the steady warmth of the weather sustains the vital actions; while the circumstances mentioned by Dr. Hooker must render electrical vicissitudes slight and infrequent, and hence their exemption from the so-called miasmatic diseases.[1]

Not only are these diseases less prevalent and less severe when vegetable decomposition is at its height, but, as I have said above, they frequently exist and are often most fatal in localities where there is absolutely no vegetable matter to be found, and where, therefore, there can be no such decomposition. In illustration of this remark a few examples may not be inappropriately cited; though the belief in marsh effluvia is so deeply rooted in the minds of men that the strongest possible array of facts will hardly suffice to eradicate it. Totally irreconcilable with the theory popularly received, they furnish their own solution; for circumstances—a loose soil penetrable and sandy, intense heat, and water within a few inches only of the surface—could scarcely be imagined more favorable to rapid evaporation, and the consequent production of a condition negatively electrical.

Dr. Ferguson informs us that "in the most unhealthy parts of Spain we may in vain, towards the close of summer, look for lochs, marshes, ditches, pools, or even vegetation. Spain, generally speaking, is then, though as prolific of endemic fever as Walcheren, be-

[1] To circumstances not dissimilar may be ascribed the exemption from fever of the inhabitants of the Dismal Swamp, in Virginia, and also of the people dwelling on the large tracts of marsh in Scotland and Ireland, in which peat-moss abounds. A similar exemption has been observed in the lower part of the great humid river-plain of the Amazon. With the exception of a short period, from 1850 to 1855, the salubrity of Pará was quite remarkable for a city lying in the delta of a great river in the middle of the tropics, and half surrounded by swamps. —*The Naturalist on the Amazon.* By Henry Walter Bates.

yond all doubt one of the driest countries in Europe; and it is not until it has again been made one of the wettest by the periodical rains, with its vegetation and aquatic weeds restored, that it can be called healthy, or habitable, with any degree of safety."[1]

"In the year 1809, several regiments of the British army in Spain took up an encampment in a hilly ravine which had lately become a watercourse. Pools of water remained here and there among the rocks so pure that the soldiers were anxious to bivouac among them for the sake of using the water. Several of them were seized with violent remitting fever before they could move from the bivouac next morning. Till then it had always been held among us that vegetable decomposition was essential to the production of pestiferous miasmata; but in the instance of the half-dried ravine before us, from the rocky bed of which (as the soil would never lie for the torrents) the very existence even of vegetation was impossible, it proved as pestiferous as the bed of a fen."

"In August, 1794, after a very hot and dry summer, the British army in Holland encamped at Rosendaal and Oosterhout. The soil in both places was a level plain of sand, with a perfectly dry surface, where no vegetation existed or could exist, but stunted heath plants. It was universally percolated to within a few inches of the surface with water, which so far from being putrid was perfectly potable. Here fevers of the remittent and intermittent type appeared among the troops in great abundance. The soil of Walcheren is precisely similar. Sir Gilbert Blane describes it as consisting 'of a fine, white sand, known in the eastern counties of England by the name of silt, and about a third part clay.' It was after a dry and hot summer, also, that the British army suffered in that island from the endemic fever to a degree almost unprecedented in the annals of warfare."

In some instances this insalubrity appears to be inherent in the nature of the soil, independently of all extraneous circumstances. The magnetic hills of the southern peninsula of India, especially those of Tavachymalle, are adduced by Mr. Craig, from a paper by Dr. Heyne in the tenth number of the *Madras Medical Journal*, containing an account of the fever which is endemical there, as a remarkable example of the irregularity and inequality of the electric tension hence arising. Wherever the iron granite rocks are found, which readily fall into a state of disintegration owing to the

[1] Nature and History of Marsh Poison.—*Ed. Phil. Trans.*

absence of latent electricity—the binding principle in all matter—the malignant peculiarity is uniformly met with.

Instances to the same purport as those related by Dr. Ferguson might be adduced in number sufficient to fill a volume, but it is hardly necessary to say more in refutation of a doctrine, the inconsistency of which with such well-known facts has already led to its partial abandonment by several writers of authority, and the substitution therefor of the modified hypothesis of an invisible, gaseous, specific, and poisonous emanation from the earth, which they call malaria, a term of wider and more indefinite signification, which does not necessarily imply either vegetable or animal decomposition; a substitution, however, which merely covers our ignorance, and does not advance one step in the way of a sound explanation. Like its prototype, moreover, it has no foundation in fact, and the whole reasoning is therefore inconclusive and erroneous. Much talent and ingenuity have been expended on this subject; it had become a settled article of medical faith, and it is perhaps not surprising that learned and able men should cling pertinaciously to a doctrine which they had been early taught as one of the first principles of science, willing to accept any modification rather than consent to its total abandonment; and, shutting their eyes to almost palpable truth, invest the creature of their imagination with various strange and contradictory attributes.

Thus we are gravely told that it is especially dangerous at night; that, lark-like, it loves the ground; is attracted by, and adheres to trees; is absorbed by water; transported by the wind, seeking, like the eagle, some high nest, etc. etc.; every one of which, as well as other properties or laws, may be much more rationally and probably accounted for on a very different hypothesis. A single example will suffice.

"You will readily understand," says Dr. Watson, "how the miasmata will roll up and hang accumulated upon the side of a hill towards which a current of air sets steadily from or across a neighboring marsh. Nay, the poison may be thus blown *over* a hill, and deposited on the other side of it."[1] In illustration of this he adduces the following circumstance related by Dr. Ferguson; but how much more obvious and reasonable the explanation, that the atmosphere of the marsh, charged with moisture and driven by the wind, reaches, and with its gravity and conducting power

[1] Lectures on the Principles and Practice of Physic. Vol. i. p. 764.

already greater than that of the surrounding air, increased by condensation, necessarily overlaps the first hill, while ere it traverses the intervening distance, it is resolved, like the luckless prayers sometimes offered to the heathen divinities, into thin air, and never attains the second!

"The beautiful port of Prince Rupert's, in the island of Dominica, is a peninsula which comprehends two hills of a remarkable form, joined to the mainland by a flat and very marshy square isthmus to windward, of about three-quarters of a mile in extent. The two hills jut right out on the same line into the sea, by which they are on three sides encompassed. The inner hill, of a slender pyramidal form, rises from a narrow base nearly perpendicular above and across the marsh from sea to sea, so as completely to shut it out from the port. The outer hill is a round backed bluff promontory which breaks off abruptly in the manner of a precipice above the sea. Between the hills runs a very clean valley where all the establishments of the garrison were originally placed; the whole space within the peninsula being the driest, cleanest, and healthiest surface conceivable. It was speedily found that the barracks in the valley were very unhealthy, and to remedy this fault advantage was taken of a recess or platform near the top of the inner hill to construct a barrack which was completely concealed by the crest of the hill from the view of the marsh on the outside, and at least three hundred feet above it; but it proved to be pestiferous beyond belief. In fact no white man could possibly live there, and it was obliged to be abandoned. At the time this was going on, it was discovered that a quarter which had been built on the outer hill, on nearly the same line of elevation, and exactly five hundred yards further removed from the swamp, was perfectly healthy, not a single case of fever having occurred in it from the time it was built."

There is no circumstance, indeed, connected with our autumnal fevers; their endemic, and, occasionally, epidemic prevalence, the influence of moisture, the comparative exemption of large cities, the agency of winds, trees, water, and a thousand other things deemed curious and inexplicable, which cannot be more scientifically accounted for on the electrical than on the miasmatic hypothesis; and the former has the additional advantage of substituting an adequate, existing, probable, and recognizable cause, for one which rests on no certain foundation, eludes all chemical scrutiny, fails to account satisfactorily for the phenomena, and is, to a great

extent, if not altogether, imaginary. The objection to this view, that disturbances of the electrical equilibrium are of continual occurrence, without being followed by such effects as are here attributed to them, is more specious than sound. It fails, as I have elsewhere observed, in not appreciating the consequences of the prolonged heat of summer, which, by exhausting the nervous energy, leaves the system in the early autumnal months weak, susceptible, and predisposed to disease; and it is, moreover, not altogether true in fact, for intermittent and remittent fevers are observed, though, of course, much less frequently, at other seasons of the year also.[1] As winter approaches the invigorating influence of cold is felt in the increase of nervous vigor; oxygen is breathed in greater quantity with a denser atmosphere; the processes of digestion and assimilation being more actively performed, a greater quantity of vital electricity is generated; reaction follows the previous depression; and the predisposition subsequently changes to other forms of morbid action. It is to this circumstance, and *not* to the destruction by frost, of malarious exhalations, that the cessation of our autumnal fevers is to be ascribed.

I do not deny that gases and foul emanations arising from the decomposition of animal and vegetable matters, especially those which vitiate the atmosphere of our large cities—where, being less exposed to the action of winds, they probably exist in a non-concentrated state—are a concurrent and efficient cause of disease.[2] They are often present in a degree sensibly offensive, and cannot

[1] It would seem that during the existence in the atmosphere in an unusual degree of a principle analogous to the nervous force, or, if the expression be preferred, the same principle in a modified form, the functions of the brain are less vigorously performed than under other circumstances; hence the acceleration of the pulse, to compensate for its diminished power, the relaxation of the capillaries, both of the skin and mucous membrane; hence the phenomena attending sunstroke, less indicative of increased action than of depression; and hence, also, the mental incapacity, the weakness, lassitude, and exhaustion of the physical powers, consequent upon the presence of long-continued heat, rendering the system, as has been shown, an easy prey to disease of every kind.

[2] There are too many instances on record of the mischievous effects of human effluvia more especially, even when inoperative upon the individuals producing them, to admit of any doubt on this subject. Thus we are told that at assizes formerly held in England, when the jails were in a much worse condition than they now are, the persons situated to the leeward of the prisoners who were themselves in usual health, were sometimes attacked by fever of a typhus character produced by the foul air which blew upon them.

be otherwise than prejudicial to health; though not, perhaps, to the degree or in the manner generally supposed. For not only are they usually of very local origin, and therefore soon diluted by dispersion into the surrounding air, but the atmosphere, by the generation of ozone—said to be one of the most powerful disinfectants with which we are acquainted—contains within itself the means of its own purification. The chief predisposing cause is heat, and this, if excessive and long continued, culminates in yellow fever; a disease which is endemic in those countries where that condition annually exists, and only requires an atmosphere negatively electrical to give full effect to its injurious influence. The increased evaporation which takes place along the line of junction of land and water, producing more active electrical changes, and, perhaps, the greater contamination of the air from the embouchure of sewers, etc., account for the first appearance of the disease in the immediate vicinity of a river, or of the sea, upon which, places subject to it are situated. Yellow fever, as formerly observed, is an inflammatory affection which expends its force generally and principally on the stomach and collatitious viscera, but may also be complicated with inflammation of other parts predisposed to morbid action. It runs its course with great rapidity, and derives its fatality as well from its involving vital organs, as from its being engrafted on an exhausted state of the system.

The crews of vessels who have continued in good health while at sea, are often attacked by yellow fever on arriving at ports where the circumstances which give rise to that disease exist in a high degree—though it may not previously have made its appearance among the inhabitants, who have been in some measure accustomed to their impression—and are unjustly charged with having brought it from the places whence they sailed. After a voyage during which, from the constant influence of a moist atmosphere, the vital forces are rather depressed below, than elevated above their normal condition, they not only exchange a healthy air for one rarefied and impure, but their duties generally become more laborious and exhausting; and the system thus predisposed, with its energies perhaps further impaired by excesses of various kinds, is more readily affected by the electrical fluctuations which are produced by the action of the sun upon the land and water. The earth, as we all know, receives and radiates far more heat than the water, and evaporation, with all the circumstances connected with

electrical change and abstraction is more active along the line of separation. Vessels which lie at some distance from the shore are comparatively exempt, unless they contain within themselves the seeds of disease; and hence the notion of the supposed absorption of miasmata by water.

"In tropical regions, the vessels at sea are often attacked with severe and deadly disease, although far removed from all kinds of miasms and emanations from the soil. The causes which operate in such circumstances must arise from the ship itself, or from the sea which everywhere surrounds it. Nothing but the vapor of pure water can arise from the sea by the operation of heat; and the evaporation can never be so copious as it is from burning land recently covered with rain. In considering the circumstances of the ship itself, we find that it is constructed of wood; and this material is a good non-conductor of electricity, and the crew of the vessel are thereby nearly insulated. It is well known that a ship which is kept perfectly dry is much more favorable to health than one which is leaky and always damp. During the operation of washing the deck under the rays of a tropical sun, there is produced from the great heat of the timber of the deck a very speedy evaporation. From a conviction that attention to cleanliness is required to prevent sickness on board vessels in hot climates the masters take care to institute a regular routine of washing and scrubbing. I have heard of vessels which have suffered dreadfully from yellow fever while the decks were visited with watery ablutions many times a day. On the contrary, in those vessels where strict attention is paid to have the ship thoroughly dry throughout, sickness of the people is much more seldom and more mild."[1]

The rapid evaporation of the water thus thrown upon, and imbibed by the timbers of the vessel, produces a comparatively negative electrical condition; and to the consequent abstraction of vital electricity from the crew, the sickness is very correctly ascribed.

It is no valid objection to the electrical theory, that the effect does not immediately follow the cause, nor that, in some cases, a period nearly definite is observed to elapse after exposure. Development into morbid action, though obeying a general law, will vary in some measure according to the intensity of the impression, the resistance opposed to it, and the nature and force of the circumstances which awaken it into life. Were it not indeed for some

[1] Mr. Craig.

accidental occurrence, that impression might long lie dormant, the system accommodating itself without much apparent disturbance to a lower grade of vitality. A generally uniform interval will, however, be found to exist, for time is necessarily required to produce a series of events ending in unequivocal disease. The organism has received a blow under which it reels, but does not immediately succumb. There is sufficient nervous energy remaining to carry on the vital functions for a while, though with progressive difficulty, and more or less discomfort. This is the formative, inchoative, or, as it has been termed with reference to some supposed action of poisonous matter upon the blood, the incubative stage; and is continued—the system gradually losing power—until positive disability ensues, and the agency of the *vis medicatrix* is invoked to restore through the reaction which it establishes, the impaired cerebral functions.

There is nothing in all this more remarkable than we daily observe in the periodicity of fever; which is susceptible of the same explanation, and obeys a duration—quotidian, tertian, quartan, etc.—corresponding to the strength of the impression and the condition of the individual. The rationale thus briefly alluded to may be stated, where there is no inflammatory complication, in fuller detail as follows: Congestion followed by rigor takes place in the organs connected with the portal circulation—the liver, spleen, etc.—as being those most predisposed to disease; and by means of the febrile movement thereby occasioned, the nervous energy is not only temporarily restored, but its normal degree actually transcended. This, in its turn, is necessarily followed by exhaustion, and the process is thus indefinitely repeated, until the system either yields altogether, or, arousing itself to shake off the incubus which oppresses it—aided in most instances by art—resumes its healthy action; the severest paroxysm, by the vigorous reaction which it induces, being frequently the last.

The tendency of the other affections to assimilate themselves to the type of the prevailing disease, is also what might, *à priori*, be anticipated. The determination in each epidemic, owing to different predisposing causes, inclines to some particular organ or tissue, whence it derives its distinguishing characteristic; but this may not be in every person the part which especially invites disease; other organs in particular cases may be more predisposed to take on morbid action, and hence disorders of various kinds coexist; all,

however, if not actually originating in the same cause, necessarily affected by the same general influence.

That such diversity of effect should be produced by the same morbific cause, constitutes, as has been seen, no proper argument against the hypothesis which I advocate. Man, in his ignorance, is fond of multiplying causes, but science is daily demonstrating the simplicity of truth. In the present instance there is obviously no necessity for such multiplication. The human frame is so constituted, that whatever impairs the energy of its controlling organ diminishes, of course, the supply of nervous power to all parts of the body; and this defective innervation acting upon the different predispositions, may give rise to aberrations as various as there are tissues and organs to be acted upon. Thus, in the dermoid tissue we may have derangement of the capillary circulation, of the exhalant vessels, or of its secretory apparatus; constituting respectively scarlet fever, measles, and smallpox; or we may have cholera from the same cause directed to the mucous membrane of the stomach and bowels; or any one of the phlegmasiæ; according as the development of latent imperfection, or accidental causes may determine. To those, therefore, who consider the complicated organism of the human system, it will not appear strange that results apparently so different, and yet in reality essentially the same, should be produced through the instrumentality of a single principle, directed in its morbid manifestations by predispositions arising from a variety of circumstances, existing in countless combinations, and involving whole communities, or affecting individuals only.

The remark made by Dr. Brady to Sydenham, "that no physician hitherto has attentively considered the force and influence of the atmosphere upon human bodies, nor yet sufficiently ascertained the part it plays in prolonging human life," is true in all its extent, even at the present day. For though note has been diligently taken of many particulars connected with its more obvious properties, the record has been almost useless notwithstanding the labor bestowed upon it, partly because proper comparison has not been made with other localities, and legitimate deductions drawn by those who framed the tables, but chiefly owing to the fact that its more ethereal and imponderable constituents, those which exert the greatest influence over the human system, and to the action of which the others are merely subsidiary, have been either unknown

or entirely overlooked. No valuable results will be obtained from any observations, however accurately made, in which these are not included; and the whole subject, moreover, must be carefully studied with especial reference to the prevailing diseases. In Scotland there is a journal exclusively devoted to meteorology, and it will no doubt give a great and healthy impulse to the cultivation of that branch of science. The editor, Mr. Glaisher, observes, in a recent number, that "were the meteorology of our towns carefully ascertained and collated with that of the metropolis, and both together with that of the country generally, in a short time we should be in a condition to elaborate a clear insight into the meteorological causes of cholera, influenza, and many phases of disease which now burst upon us with the suddenness and devastating power of a divine and wrathful visitation."

"When we reflect," says a writer in the *British and Foreign Medico-Chirurgical Review*, "on the complicated agencies to which man is exposed irrespective of the atmosphere, and the marvellous complicity of action of the atmosphere itself, operating through the medium of heat, light, electricity, magnetism, aqueous vapor, and variable mechanical pressure, to say nothing of its more recondite elements, ozone and miasmata, we cannot be surprised that we are yet merely in the dawn of climatological science." A still higher authority, Sir Henry Holland, has the following remarks in relation to this subject: "Little though its influence has yet been defined, I believe that the *electrical* strata of the atmosphere is that of all its conditions which has most important and diffused effects on the animal economy; more rapid and pervading than any other; and, as one of the vital stimuli, more intimately allied to the functions of the nervous system. It is that, further, which most closely blends itself, either as cause or effect, with all the other meteorological changes; producing thereby many of the difficulties already noticed in estimating their relative amount of influence. When modern science has shown us that every chemical action is attended by, if not identical with electrical change; that the processes of vegetation, as well as those of animal life, involve unceasing alteration in its states; that no two bodies can be present to each other of different temperature, nor even separate parts of the same body be differently heated, without evolution of this agent; that every act of evaporation, or deposition of water on the surface of the globe, has similar effect of change, even the spray of a waterfall sensibly altering the balance of electricity around it—we may well

understand how wide is the circle of these mutual changes, and how important in the economy of nature, including in this the existence and functions of organic life itself."

The manner in which morbid action follows the abstraction of electricity from the system, is sufficiently indicated by what has been already said, but it may perhaps be made still clearer by one or two additional examples; and scarlet fever, as being, in its uncomplicated form, a familiar instance of a general inflammatory affection, will furnish an opposite illustration. This disease, though occasionally observed at every season of the year, prevails most extensively in autumn and spring—periods during which electrical fluctuations are greatest and their influence is promoted by the various meteorological circumstances so often mentioned before—and, as might be expected, is chiefly confined to children, whose power of resisting hurtful impressions is less than that of persons of mature age and vigor. The action of the brain and nervous system being depressed, or otherwise disturbed by the rapid abstraction of sensorial energy, and their control over the capillaries lessened, these consequently become dilated; the circulation through them is retarded, and a state of things is induced closely bordering on inflammation. This, though general in all the tissues, is more particularly observed in the mucous membrane of the digestive system, and in the skin; as evinced in the former by the redness of the throat, and the projecting papillæ of the tongue—sometimes also by the occurrence of nausea or diarrhœa—and in the latter by the scarlet efflorescence and other symptoms of increased action, the predominance of which in this tissue commonly indicates a tractable form of the complaint. Meanwhile the brain reacting against the morbific agency, separates and transmits the nervous energy as before; but there is now a demand for a greater supply in order to restore the impaired tonicity of the capillaries;[1] this restoration is accomplished through the exaltation of its functions occasioned by the febrile movement—an action of salutary tendency when it does not transcend the required limits—and after a commotion of greater or less severity, occupying, necessarily, a nearly definite period, the system reverts to a state of convalescence. Such is the order of things in scarlatina simplex. In the anginose variety the pathological alterations proceed one step

[1] It is this demand, requiring all the ability of the system to sustain it, which renders depletion, and other measures producing still further exhaustion, so dangerous in the treatment of this disease.

farther. The circulation through a portion of the capillaries is not only retarded, but absolutely arrested; congestion follows, and inflammation is set up in the fauces—where, from the laxity of the parts, and the exposed condition of the vessels, we should naturally expect to find it. In still more aggravated grades of the malady, whether owing to the intensity of the cause, feebleness of the constitution, or some other circumstance affecting the individual, the powers of life are prostrated, in many instances beyond the capability of reaction; the brain being deprived of its nervous energy, is thrown into disorder, delirium or coma ensues; and after a struggle of varying duration, death generally closes the scene—often supervening in a very few hours.

The year 1856 presented meteorological conditions favorable to the production of this disease; and it consequently prevailed very extensively. The winter was excessively severe, and the cold was protracted throughout the spring. The early part of the summer was very warm, with the coolest August that had been known for a long period of time. The autumn was open and variable, and the mortality towards its close amounted to more than forty cases a week. A few consecutive days of clear, cold, and dry weather occurred in the early part of December, and were followed by a marked diminution of the complaint—the number of deaths for the week following being only thirty. It subsequently became chilly, wet, and variable, and the mortality again increased beyond any previous example. The whole number of deaths in Philadelphia during the year, from this disease alone, was nearly or quite one thousand. In New York it amounted to more than twelve hundred.

The origin of measles may be explained in like manner. The difference being, that in scarlet fever the effect of the impaired innervation is chiefly seen in the deranged capillary circulation; whereas in measles, while it implicates the pulmonary, rather than the gastro-mucous tissue, it receives from some predisposing cause—perhaps a somewhat greater degree of cold, or the same degree acting upon a system less debilitated, as in the spring—a determination to a different part of the skin; probably its exhalant vessels. In smallpox another and more secretory portion of this composite structure is affected, and hence its contagious character.

If I were asked what it is that essentially constitutes nervous, typhoid, or enteric fever, as it is sometimes indifferently called, I would reply, depression of nervous power—it matters little how induced, whether by excessive fatigue, enfeebling the action of the

brain, or the too rapid abstraction of cerebral force—and, generally, as its immediate consequence, congestion of the intestinal mucous membrane, through some peculiar predisposition to affection of that part. According to the degree of the reaction—by which the brain recovers its energy and the membrane its healthy condition—there will be, supposing it to be uncomplicated with affection of other parts, an open and inflammatory, or an insidious, depressed, and adynamic state of things. The morbid action is prone to linger long in the glandular structure of the ilium, and other organs may become implicated in the progress of the disease; but its essential characteristics are briefly stated as above.

The application of the same mode of reasoning to the phlegmasiæ is sufficiently obvious. An individual from lying on the damp ground, getting wet, or from some exposure in a raw and chilly state of the atmosphere—the physical powers being perhaps depressed by fasting, fatigue, or some other predisposing cause; or, it may be, from undue fatigue alone—becomes unwell, and is said, in common language, to have "taken cold." More correctly speaking, the sensorial energy or animal electricity has been abstracted from the system with greater rapidity than it could be generated without disturbance of the cerebral functions; the effect is felt in the diminished innervation of some organ liable from congenital, or acquired predisposition, to fall into morbid action; and as a consequence, inflammation takes place, either in its parenchyma or its investing membrane, as circumstances may determine.

The exanthemata prevail chiefly in early life, when the nervous system is not only predominant and impressible, but there is, moreover, from their greater functional activity, a natural tendency to affections of the dermoid and mucous tissues; the predisposition in after years inclining rather to diseases of the organic system.[1] The exemption from a second attack, though by no means so general as is commonly supposed, increases with the more confirmed and vigorous action of the brain; and these diseases, therefore, unless there be a strong constitutional tendency, or the predisposing causes exist in a higher degree, rarely affect adults.

When the meteorological conditions are favorable to the production of smallpox, vaccination will confer no immunity; as is proved by the occasional general prevalence of what is termed the

[1] In children the exanthemata are frequently ushered in by convulsions or coma, and I have known the same thing to happen also in intermittent and other fevers; showing the primary action of the morbific cause upon the brain.

varioloid disease; which attacks alike the protected and the unprotected. Among the sources of fallacy on this subject, are the more confirmed vitality, and different morbid predispositions of later life; the infrequent occurrence in a high degree of the conditions, remote and proximate, favorable to the generation of variola; and the fact that many of the depressing causes which give effect to those conditions—want of food, and clothing, neglect of cleanliness, impure air, etc. etc.—are, in this country, seldom seen in combination; unless it be among our aboriginal tribes, who suffer terribly from this scourge. That confidence in the efficacy of vaccination has been diminished of late years, it were vain to deny; for its advocates, driven from the ground of perfect exemption, have been obliged to resort to a modified protection—creating the term "varioloid," to explain a degree of mildness, which is owing to less severity of epidemic influence, improved modes of living, and a more rational treatment—and are, moreover, divided among themselves as to the necessity of the repeated, and even septennial employment of their supposed prophylactic.

I am far from supposing that disturbance of the electrical equilibrium is the sole cause of morbid action. Disease, once induced, has, in some instances, the power of self propagation; and often originates, moreover, from other causes, operating as well within as without the individual; but when it prevails either endemically, or epidemically, or in sporadic cases of complaints sometimes epidemic, where there has been no exposure to contagion; and on all occasions where it is said to arise from "cold;" its etiology I believe to be as I have described. Whatever indeed enfeebles the action of the brain and disturbs the innervation, must produce, under similar predisposing influences, the same results; for it makes little practical difference whether the nervous energy is too sparingly supplied, or is too rapidly abstracted. The *modus operandi* is alike in both cases. The impression is primarily made on the nervous system, congestion ensues in the vascular tissue of some organ—for it seldom happens that all parts of the frame possess equal soundness and vitality—and the various morbid aberrations of which I have spoken, with imperfect secretions, vitiation of the blood from the retention of effete materials, etc. etc., follow in its train. Sporadic cases of smallpox which are not traceable to any contagious source are of frequent occurrence. Both that disease and scarlet fever also, are sometimes produced by the nervous exhaustion occasioned by fatigue alone. Instances of this kind have

occurred in my own practice; and in further confirmation, I may remark, that Evelyn states in his *Diary*, that one of the princes of the royal family was attacked by smallpox of a confluent and fatal character, after excessive dancing.[1]

When the predisposition is wanting, even contagion will be nearly, or altogether inoperative; and people are often exposed to it with entire immunity. Variola itself, under such circumstances, will rarely spread beyond the individual affected; and may even give rise to disease of a different kind. The poisonous emanations would, therefore, seem to operate, in these cases at least, not so much from any inherent, or specific property, whereby the disease necessarily reproduces itself, as from their general action in depressing, or subverting cerebral power — already impaired by watching, fatigue, fasting, anxiety, impure air, immature or unconfirmed vitality, and a thousand other circumstances—and the consequent causation of any complaint to which predisposition existed; which, in most cases, would, of course, be that by which the contagion was produced. Variolous fever alone, without affection of the skin, is not uncommon; and I have seen cases of fatal congestive fever, without the characteristic eruption of smallpox, manifestly caused by attendance on the confluent variety of that malady. To this inaptitude some of the fallacies regarding vaccination, and the security which smallpox itself affords against a second attack, may not improbably be attributed. The general predisposition, individual tendency, the negatively electrical condition of the air of apartments vitiated by respiration, and other depressing influences, will satisfactorily account for much that in many diseases is ascribed to contagion. It is very desirable to be able to disabuse the minds of people of all really unfounded fear on this subject, for selfish apprehensions thence arising, sometimes interfere materially with the comfort of families and the welfare of the sick; to the extent, not unfrequently, of violating the amenities of society, and even extinguishing the charities of our nature.

The subject opens a wide field for observation and reflection, and will require on very many topics an entire reconstruction of

[1] The late Bishop Boone, speaking of his narrow escape from shipwreck, in a storm which he encountered in a voyage from Aden to Ceylon, observes: "Our last danger was from pestilence, or ship fever. You can have no idea of the smell from such masses of wet leather, and decaying clothes, etc., to which we had added dead rats and poultry, etc., and, to crown all, *three of the crew were taken down with smallpox.*"

medical opinion. Several complaints now attributed to contagion, will be found to spring from a cause which no isolation could evade; demonstrating thus the inutility and folly, as well as the mischief of quarantine regulations in regard to many diseases to which they are now applied. Not only marsh miasmata and malaria, but the whole tribe of atmospherical miasms, with the protective virtue of vaccination, and several other long-cherished, and widely-adopted opinions, are destined to fall before the more rational theory which it inculcates; while it cannot fail to exercise, also, a beneficial effect upon practice, in making the preservation and restoration of nervous energy a prominent object of regard both in health and disease.

The fiction that there are floating in the atmosphere miasms which enter into the circulation by respiration or otherwise, acting as a poison to the blood, and severally producing scarlet fever, measles, smallpox, etc.—for these diseases often prevail in the same neighborhood or household, and two of them sometimes in the same person—thus rendering the air we breathe, and which a merciful Providence intended to be a life-giving principle to man, a magazine of hostile elements warring for his destruction, may have appeared clear and satisfactory in the age in which it was invented; but, viewed in the light of modern discovery, it is, in my judgment, as absurd as I believe it to be unfounded.

It might, perhaps, be thought that disorders originating in the abstraction of vital electricity should be cured by the artificial supply of that principle; and this supposition would not be unreasonable if our bodies, instead of being organized living systems, were unformed and inanimate machines. In the actual constitution of things, however, other morbid actions speedily follow the temporary relaxation of cerebral or nervous control; inflammation is set up; the secretions are imperfectly performed; depuration of the blood is not properly effected; and results are produced which can only be obviated or repaired in accordance with the laws which govern the animal economy both in health and disease. In actual practice I have not found electricity, though deserving, perhaps, of a more extended employment than it has hitherto received, of much value in the treatment of complaints, functional and nervous —to which it is chiefly applicable—until the system had been brought by other measures nearly or quite to its normal condition, and the suspended function only required an appropriate stimulus to awaken it into activity.

It will undoubtedly often give temporary relief in neuralgia and other nervous affections, but the same rule holds good here as in other cases. Over-stimulation, if unduly protracted, is followed by exhaustion; and the substitution of an artificial for a natural stimulus, however great the analogy between them, will necessarily cause more or less impairment of that thus superseded or placed in abeyance. Dr. Radcliffe, indeed, informs us as the result of his observation, that continuous currents of low electric tension, instead of possessing the restorative power which has been anticipated from them, seem to have a directly paralyzing effect upon that part of a motor nerve which is exposed to their influence. As a temporary stimulus it is often very useful, but the sanguine expectations which have been entertained of electricity as a curative agent have certainly been disappointed; and, like many other things good in themselves, it has, perhaps, been unduly depreciated; its practical application falling to a great extent into the hands of mercenary and unprincipled pretenders, by whom, no doubt, much mischief has been done. It would, certainly, be rash and unphilosophical to assert positively that happier results might not be produced by more refined machinery and better modes of application, as proposed by Duchenne and others.

I have purposely avoided all discussion of the question respecting the identity of electricity and the nervous force. The modification which, on that supposition, the former must be admitted to have undergone, will be regarded by many, notwithstanding the analogy between them, as evincing a radical diversity. Nor, as has been observed, is the affirmative assumption necessary for the establishment of the theory which I have set forth. It is sufficient that there should be such a reciprocal relation, that fluctuations in the quantity of the electricity ordinarily present on the surface of the earth and in the surrounding atmosphere, should produce a corresponding change in the vital or animal electricity belonging to the human system; and this much, I presume, will be admitted by all physiologists.

It is not to be supposed that a theory which allows of no divided empire, but seeks to exalt itself upon the ruin of what composes so large a part of medical literature, supplies so much of medical phraseology, and has exercised an influence so controlling over medical opinion, will be received without strong opposition. A host of prejudices will start up in arms against it, and may deprive it in many minds, of the consideration which it merits. It

will be regarded by the indolent as among the novelties which disturb their peace; and others unmindful of the fact that correct meteorological observations, embracing all the constituent principles of the atmosphere, and having especial reference to prevailing disease, have yet to be made; and not fully aware perhaps of the difficulties attending investigations on the living organism, will be disposed to class it with the baseless hypotheses which it aims to supplant. Such prejudices and prepossessions should not be permitted to interpose obstacles to the pursuit, and the adoption of truth. If, as I firmly believe, it be founded on fact, it will ultimately triumph over all opposition; and, if otherwise, it should be refuted and rejected. It has been held by me, with increasing conviction during the greater part of my professional life, extending over a period of more than forty years; and from the clear insight which it gives into much that without it would be dark and contradictory, I should be happy to impart the confidence which I feel, in equal degree to others.

To my mind it not only harmonizes and elucidates many discordant and otherwise inexplicable phenomena, but inculcates a rational and conservative practice; and while, by its adoption, we substitute a simple, intelligible, and effective etiology for one complex, contradictory and inadequate, we get rid of much of the unfounded theory, false reasoning, and unmeaning phraseology which have so long bewildered and disgraced our profession.

It is certainly more philosophical, and more in accordance with the operations of the Divine Author of nature, who produces effects the most diverse and wonderful through the agency of a few simple elements, to ascribe the causation of the diseases we have been considering to a single instrumentality, analogous to the nervous force, and capable, from its potent, fluctuating, and all-pervading character, of accomplishing, through the governing organ of the animal economy, all that is thus attributed to it; than, like the heathen of the olden time, who recognized behind every phenomenon a god with passions as variable as those of men, to create a deity, or assign a different cause for every variety of morbid action, and people the invisible realms of medicine with as many emanations and miasms as there are diseases incident to the human frame.

Notwithstanding all that has been written on the subject of malaria, we are as far from any real knowledge of its nature as we were when its existence was first announced. We are con-

versant, indeed, with its supposed effects; but of its cause and essence we are profoundly ignorant. It has baffled all observation, eluded all research, and though everywhere, and by everybody, regarded and treated as an undoubted entity and a fruitful source of evil, is, in my judgment, a myth, a mere phantasm of the imagination, resting, as I have before remarked, on the veriest hypothesis.

It is gratifying to know that the medical mind, so long held in the thraldom of authority, is beginning to break the flimsy fetters which have bound it, and to assert its prerogative of independent thought. I have conversed, of late years more especially, with intelligent physicians from various parts of our country, and have found, in many of them, a strong feeling of dissatisfaction with the doctrines prevalent on this subject; though they knew of nothing better to substitute for them. Contradicted by facts of familiar observation and daily occurrence, they are evidently losing their hold on the thoughtful and intellectual; and must, ere long, give place to views more in accordance with the organization of the human frame, and the dictates of a sounder philosophy.

It should not be forgotten that those by whom these doctrines were originally taught, lived before the era of modern discovery, when electricity as a science did not exist; when its probable identity with light and caloric was unsuspected, and when its action upon the animal frame and the marvels of the telegraph were unknown. The hypotheses which they invented to combine, harmonize, and explain the phenomena which they observed, were not behind the philosophy of their age; indeed, they may be said to have been far in advance of it, for they have survived many other groundless assumptions, both in this and other branches of knowledge; and their exposition has been received, and their authority unchallenged, almost until now. The fault is all our own, because, in our indolence or indifference, we have refused to examine the grounds on which their theories rested, and blindly adopting their antiquated lore, have stereotyped their errors, and cling to them as firmly as though they were rigid deductions drawn amid the brighter revelations in physical science which it is our privilege to enjoy. No theory of disease, in fact, which does not recognize the influence of the atmosphere, as well its sensible conditions as its imponderable and recondite elements, is properly entitled to any serious attention.

The history of the recently discovered principle called ozone,

the existence of which, however, it must be stated (such is the uncertainty of medical opinion) is still doubted by many—at first regarded as electrified oxygen, but now more generally supposed to be a peroxide of nitrogen—furnishes a remarkable example of the importance and advantage of such researches. Generated by the action of electricity on atmospheric air and watery vapor, this new and powerful agent, strong in its obvious qualities, and in the chemical reaction which it exerts on whatever is exposed to its influence, is already considered as one of the most active oxidizers, disinfectants, and deodorizers in nature; purifying the air in which it is developed, and rendering innocuous the poisonous gases and other offensive impregnations by which it is constantly contaminated. It is said to impart to the solar rays the bleaching property which they possess, to act as a direct stimulant to animal and vegetable life, to play a conspicuous part in the production of various important pathological results, and to display, generally, such striking therapeutical virtues as cannot fail, if a tithe of what is attributed to it be true, to render it an efficient agent in the prevention and cure of many diseases.[1]

Just views of the cause of disease constitute a very important step towards its prevention and cure; and, as might be expected, the doctrine of electrical agency is fruitful in its practical application; involving whatever may protect the system against the fluctuations of this potent and ethereal principle. It supplies us with an intelligible reason why in the selection of a country residence we should avoid localities the air of which is habitually charged with moisture, and its conducting power thereby increased, whether owing to the nature of the soil, or the windward vicinity of water; and as elevation affords comparative security—the upper strata of air being drier—why upland situations, when choice is practicable, should, of course, always be preferred. "In the same place," says Dr. Ferguson, speaking of English Harbor, Antigua, "the malaria in the level plain caused continued fever, resembling, and, I believe, identical with yellow fever; at the elevation of three hundred feet it gave rise to remittent fever, and at the height of five or six hundred feet its influence was scarcely felt at all." It teaches us, for a similar reason, not to tarry in, or travel through, insalubrious

[1] The literature of ozone is already voluminous; but a well-digested, and well-written summary of the whole subject will be found in Dr. Gaillard's Fiske Prize Essay. Much of what is ascribed to this principle is probably due to the direct action of electricity.

regions during the night; to avoid exposure, especially in feeble states of health, to the early morning and evening air of the country, when intermittent and remittent fevers are rife; and, when such exposure is unavoidable, indicates the propriety of sustaining the vital powers by a previous meal—during the digestion and assimilation of which, the system is employed in generating vital electricity—and the exhibition also of some tonic, or stimulant, in order to exalt the action of the brain.[1] It explains how it happens, that in certain seasons and during the prevalence of certain winds, situations ordinarily salubrious become unhealthy, while others usually sickly become healthful in their turn. It instructs us moreover, during the existence of any epidemic, to abstain from everything which may depress or exhaust the nervous energy, and to maintain the brain in its accustomed, or even in increased vigor, as well by the stimulus of hope and confidence, as by the use of means which exert their influence more particularly upon that organ; affording thus the probable rationale of the action of various prophylactics. Whatever, indeed, sustains and exalts the nervous power must necessarily tend to avert disease; and in the autumnal season, more especially, when the system, before its reaction under the cold of a later period, is left in a condition not unlike that of an inebriate from whom his accustomed stimulus has been withdrawn, the general prescription or use of some appropriate tonic might be expected to prove extremely useful. The same plan might be advantageously pursued also during prolonged periods of damp and chilly weather, when the air, charged with moisture, becomes actively conductive. The mortality among children,—who perhaps do not, as a general rule, receive a sufficient quantity of animal nutriment, owing to which the processes concerned in the development of vital electricity are inefficiently performed,—as well as among the aged and the infirm, might probably be greatly lessened in this way. In a late expedition up the Niger, a river so fatal to previous explorers, the health of the crew was preserved in a remarkable degree—not a single life being lost—by the administration of quinia morning and evening, with other hygienic precautions. Similar testimony is borne by our army surgeons to its value when thus employed; and the same plan might be advantageously adopted by vessels arriving at our own, or foreign ports

[1] The morning air being colder, and therefore denser, than that of the evening, a greater quantity of oxygen is breathed; and the brain, invigorated by recent sleep, is in a better condition to resist hurtful impressions.

during the prevalence of yellow fever. It guides us, furthermore, to a right practice in many complaints now somewhat empirically treated; warning us to abstain from depleting and other disturbing measures, in scarlet, typhoid, and other fevers, where the nervous energy is already impaired through the debilitating nature of the cause,—inflammation not having yet been set up in any local organ —and the subsequent reaction is merely a salutary effort of the *vis medicatrix* to restore the lost balance of the system. A want of due innervation being the primary deviation in the train of morbid action, it holds out a reasonable hope of subverting certain complaints in their incipient stage before the vascular system has become implicated, by the administration of tonics—quinia, for instance, in large doses. And where such implication has already taken place, shows—what daily experience confirms—that in inflammation of an asthenic or adynamic character, there is no necessary antagonism between the simultaneous employment of a tonic, and an antiphlogistic treatment. The ultimate effect, indeed, is very similar in both cases; we deplete in order, among other reasons, to lessen the congestion of the extreme vessels, and we exalt the nervous energy to restore their tone, and thus insure their contraction. It must be evident, however, that the existing debility is often owing to the oppression of some vital organ, the restoration of which to its functional activity is the great indication, and the means, depletory or otherwise, by which this is fulfilled, are actually tonic in their influence, from the relief which they afford to the oppressed and struggling organism. In many, perhaps in most instances, the patient is not seen at the onset of the disease, when nervous depression alone is present. This condition is speedily followed by congestion, or inflammation has supervened, demanding in most cases the preliminary employment of evacuant and revulsive measures. Even venesection is sometimes imperatively required under such circumstances. Its importance was strikingly illustrated in the treatment of the malady called in Persia, Tab i Ghash, or the fainting sickness, which appears to have been merely a congestive form of cholera without vomiting or purging; and in which, according to Dr. Bell, an English physician, who speaks from an experience of two thousand cases, it was the only curative means on which, though emetics and cathartics were useful auxiliaries, any absolute dependence could be placed.[1] When the train

[1] Dr. Robert Burns, of Frankford, acting upon well-considered theoretical views, had the courage and independence to resort to bleeding in the cholera of our own

of morbid actions has made still further advancement, and inflammation of important organs has actually supervened, there can be no rational difference of opinion with regard to the judicious employment of antiphlogistic measures; though many lives are probably lost, or health often irretrievably ruined, by the unfounded prejudices which unhappily prevail. Even here also means adapted to restore and support the general tone, are, when properly timed, often signally useful. In the management of yellow fever, for instance, on which medical opinion is still unsettled, early and copious depletion by the lancet, to abate vascular excitement and change the character of the circulating fluid; calomel in large and frequently repeated doses, to relieve visceral engorgement; and these objects attained, or in process of attainment, the liberal exhibition of quinia, to restore nervous power and the tonicity of the extreme vessels, is the practice which—due regard being had to climate, the character of the epidemic, and the circumstances of each individual case—the exercise, in a word, of that discriminating judgment which distinguishes the physician from the mere follower of prescription and routine—would follow by fair deduction from the theory which I have set forth. A combined tonic and antiphlogistic treatment—prominence being given to one or the other, according to circumstances—is also indicated in the epidemic known as the "spotted fever," or, more properly, cerebro-spinal meningitis; a disease in its intenser form almost necessarily beyond the resources of art. But the importance of the parts chiefly affected, its rapidity of progress, the impending inflammation, and the almost inevitably fatal result of any considerable organic change, would naturally suggest extreme caution in the use of tonics and stimulants in its earlier stages—especially as the prostration and debility are manifestly rather apparent than real—and lead to greater reliance, particularly in the congestive and comatose cases, on local depletion, mercurial purges and alteratives, the hot bath and other external derivatives.[1] The hypothesis suggested, removes also in many diseases—scarlatina, rubeola, cholera, etc. etc.—the dread of contagion, so mischievous in its consequences to the sick; and relieves us from the supposed necessity of purifying the blood by the elimination of an imaginary *materies morbi*, though not of remov-

country, and speaks in high terms of the pleasurable sensations and the relief which it occasioned both in his own case and many others.

[1] Dr. Burns informs me that he has successfully employed bleeding under apparently desperate circumstances in this complaint also.

ing, so far as practicable, contaminations of that fluid which are produced during the continuance of morbid action. It suggests the necessity of appropriate clothing—that is, of garments composed of non-conducting materials—as wool and silk—and of other precautionary measures in the management of children; and finally admonishes us of the importance, at all times, of preserving the vital forces in the best possible condition, and thereby of affording to the *vis medicatrix* full opportunity of accomplishing its recuperative tendencies.

The theme is a prolific one, and the ideas thus imperfectly expressed, far from exhausting the subject, must be regarded as little more than suggestive. Much patient investigation and careful induction will be required to remove all doubt, and secure their adoption by the profession; but if I have succeeded in creating even a presumption of their probability, I have accomplished all that I expected to do. Such presumption will lead to further research and more exact observations than have hitherto been made, and these are necessary to enable us to arrive at any certain conclusions.

The theory, I need hardly say, is not wholly original, for electrical fluctuations have been conjecturally assigned, with more or less confidence, as the cause of several complaints; but few attempts have hitherto been made to show by argument the grounds on which such conjecture reposed; and I am not aware that it has ever been so fully developed, or has received so extended an application as I have given to it. Dr. Wood, in his *Practice of Medicine*, states that Sir James Murray maintained in an article published in the *Dublin Press*, in the year 1844, that the true malarious agents are electro-galvanic currents and accumulations, which produce disease by disturbing the electrical equilibrium of the body; an opinion identical with that which, with wider comprehension, I have advocated in the present essay; though by what reasoning it is supported by him, I am entirely ignorant, for I have not been able to procure his paper. The only monograph[1] on the subject with which I am acquainted, is that by Mr. Craig, of Ayr, already so often referred to; and the copious extracts from which given above, abundantly manifest his entire agreement with the general doctrine which I have advocated. The leading idea, indeed, once fairly

[1] Since expanded into a volume which I have vainly endeavored to procure in this country.

admitted, would naturally lead to a similar train of reasoning; and as it was ordained of old that the testimony of two competent and unbiassed witnesses should be deemed conclusive in all matters of forensic dispute, so the elaborated conclusions of two isolated and independent minds, engaged unknown to, and independent of, each other, in the solution of the same problem, must be allowed to furnish, in their singular coincidence of opinion and argument, a strong presumption of their substantial correctness.

A very full editorial notice of Mr. Craig's paper, which originally appeared in the *London Medical Gazette*, for June, 1851, was published in the *North American Medico-Chirurgical Review*, for May, 1857, as a sequel to one of my articles on the same subject. It is too long for reproduction in this place, nor, after the free use which has been made of the pamphlet, is such reproduction necessary; but room may not be inappropriately given to the general summary or recapitulation with which the monograph concludes. It is as follows:—

"1st. That heat and electricity are identical, as the one can be converted into the other.

2d. That a large volume of electricity surrounds every primary constituent of matter, especially that form of matter which constitutes the gaseous bodies.

3d. That animal heat is supported by the electricity liberated from the primary constituents of matter during the processes of respiration, digestion, and assimilation.

4th. That electricity is evolved during these processes on the same principle as that which is evolved during the action of a galvanic arrangement.

5th. That electricity and nervous power are analogous, if not identical, as the action of one can be successfully substituted for the other.

6th. That the majority of diseases are caused either by the sudden obstruction, or slow abduction of electricity from the body.

7th. That a low state of electric tension on the surface of the earth, produced either by the operation of evaporation, or some occult movement in the great internal currents of the earth, is the remote cause of epidemic and pestilential diseases.

8th. That occasional and ordinary diseases are produced by the sudden abstraction or slow subduction of electricity from the body, or its sudden elimination during the vital processes.

9th. That since electricity is so essential to the integrity of the

vital operations, it is indispensable that measures be taken to produce its evolution, and to prevent over-radiation.

10th. That electricity is the source of vitality in vegetable life.

11th. That electricity is attracted by the fibres of the roots of plants; and by the instrumentality of the electric fluid does the plant attract its constituents from the soil.

12th. That vegetables of rapid growth require a large supply of electricity to secure their perfection and completion; and the potato is a plant of this kind.

13th. That the disease in the potato was produced by the want of nutrition.

14th. That the want of nutrition arose from defective electric agency.

15th. That the cause of the deficiency of this agency was those abstracting influences which produced low tension of electricity."