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SYNOPSIS
OF
THE SPINAL SYSTEM ;

BEING

OUTLINES OF THE CROONIAN LECTURES DELIVERED AT THE ROYAL COLLEGE OF PHYSICIANS,
IN APRIL, MDCCCL.

SYNOPSIS

OF

THE DIASTALTIC NERVOUS SYSTEM ;

BY

MARSHALL HALL, M.D. F.R.SS. L. & E.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS; FOREIGN ASSOCIATE OF THE ACADEMY OF MEDICINE
OF PARIS; ETC. ETC.

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SYNOPSIS

THE DIABETIC NERVOUS SYSTEM



MARSHALL HALL, M.D. F.R.S. & F.

LECTURE IN THE COURSE OF THE STUDY OF MEDICINE

LECTURE I

THE NERVOUS SYSTEM IN DIABETES

P R E F A C E.

IN THE following pages I have endeavoured to express, in the clearest and briefest manner, the outlines of the Spinal System, such as they have unfolded themselves to me in a long series of experiments and observations. If I have demonstrated the great extent of this system in Anatomy and Physiology, and its great value in Pathology and Practice, I have accomplished my purpose.

To treat fully of the infinite number of topics, which are here laid before the reader in mere outline, would occupy a considerable volume ; and for such a volume, in the present condition of the profession, there would not be found readers ; for—‘ Monographs do not sell’—that is, are not read. The present cheap, elementary, and compilative state of medical literature, will exclude, for a time, all original works. This *Synopsis* has been printed at my own expense.

There is only one hope : it is, that the Royal Colleges of Physicians and Surgeons, seeing and deploring this state of things, may resolve to *examine* upon original and classical works. Then, and not till then, will our literature be encouraged and become worthy of our profession ;

whilst the knowledge insured will be better than tardy latin and greek and mathematics.

Much more might be written upon this subject. The present has been too justly designated—‘the age of medical degradation.’ Whilst this is the lamentable fact, every kind of empiricism is in the ascendant.

When members of our profession shall be really and fully imbued with all its literature, they and it will take the station which is due to them. This event will constitute the true *Medical Reform*. But there are those who actually boast that they never *read*!—that is, that they are without science and without literature, that, for them, Prout and Liebig have laboured and written in vain! The result is, that our profession is indeed in a state of ‘degradation.’

When will the time arrive when the minds of Harvey, of Hunter, of Jenner, shall actuate and mould, as it were, those of the living members of our profession? There is as much difference between the productions of such minds, and the various compilations from them, as there is between a painting of Raphael and an attempted copy; whilst a true spirit of philosophical inquiry is imbibed in their perusal.

To save the time of those of my professional brethren who may favour these pages with their attention, I have endeavoured throughout to encumber them with as few words, and to enrich them with as many new and important facts and principles, and suggestions for further research, as possible. For those who wish to enter deeply into the subject, the present *Synopsis* must be taken in connection with my three ‘Memoirs,’ and my volume on the Diseases and Derangements of the Nervous System.

The term *Diastaltic*, employed throughout this volume, was the happy suggestion of my friend, Mr. Hoblyn, as congeneric with *peristaltic*. The compounds of *ὄδος* are too plain and simple to create any difficulty. Both are approved of by the Rev. Dr. Donaldson, the learned author of '*The New Cratylus*.'

The *entire and absolute Distinctness* of the *Spinal Centre*, and of the *Spinal System*, from every other part of the Nervous System; the existence, in *Anatomy* and *Physiology*, of a continuous *Diastaltic Nervous Arc*,—including an *Esodic* nerve, the *Spinal Centre*, and an *Exodic* nerve, in *essential* relation and connection with each other,—and of a *series* of such *Arcs*,—with their demonstrated *special Principle of Action*, and their *special Office* in *All the functions* of *Ingestion*, *Retention*, *Egestion*, and *Exclusion* in the *Animal Economy*, and, above all, in the vital function of *Respiration*, and, associated with peristaltic action, in *Deglutition* and *Parturition*; the application of all this to *Obstetrics*, to *Pathology*, to *Diagnosis*, to *Therapeutics*;—such are the objects of which I propose to give a glimpse in this little volume—such my Discovery—such the results of my persevering labours.

The *Spinal or Diastaltic System* is the *Seat*, originally or secondarily, of *All Spasmodic or Convulsive Affections*. Disease of the encephalon may induce such affections by contact and *irritation*, or, though distant, by *counter-pressure*, affecting the spinal system. But, ultimately, *all spasm* is of this system. On the other hand, spasmodic or convulsive disease may, in its turn, become *Epileptoid*,—may affect the cerebrum—may induce oblivium, loss of consciousness, falling, delirium, coma, paralysis. This

effect is, and can only be produced through the medium of the nerves and muscles of '*The Neck*' inclusive of the *Larynx*, that newly appreciated *Medical Region*, of which I have treated elsewhere.

I repeat, that disease of the cerebrum can only induce spasm or convulsion through the Spinal System; and that disorder or disease of the Spinal System (§ 234) can only affect the encephalon through the *nerves* and *muscles* of '*The Neck*,'—a view which, if confirmed by experience, is certainly of an extraordinary character.

The doctrine of the '*tendency*' of blood to the head, must be replaced by that of its '*impeded return*' from that region.

Having dismissed this *Synopsis*, it is my intention, notwithstanding what I have stated above, to proceed at once to fill up the outline and prepare my more complete work for the press, comprising in it all my papers on the Nervous System and its Diseases*.

* I am happy to record that my friend Mr. Henry Smith has succeeded in restoring animation to an infant born in a state of asphyxia, by *alternately* placing it in a warm bath and raising it and dashing cold water on its face; the sudden application of warmth produced a greater effect, *as an excitor of respiration*, even than that of cold!—affording a beautiful example of the influence of the principle of *alternation* in the diastaltic nervous system. (See § 353—; and § 362.)

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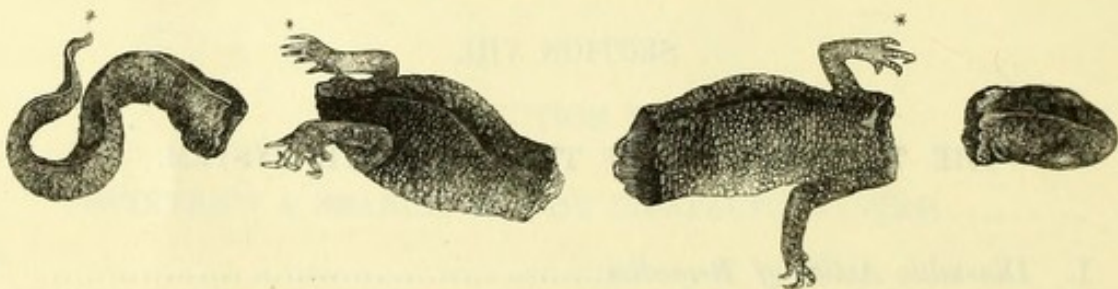
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*First Observation on the Triton.**Figure I. See § 12.*

SYNOPSIS
OF
THE SPINAL SYSTEM.

SECTION I.

THE VIS NERVOSA AND ITS LAWS OF ACTION.

§ I.—*First Observation.*

Figure 1.

1. THE following pages are intended to present a *Synopsis* of the results of some protracted investigations, and an Outline of the Croonian Lectures which I had recently the honor of delivering before the Royal College of Physicians. They will also contain the principal additions made to our knowledge of the Nervous System, since the date of the publication of my last or 'New Memoir,' in 1843.

2. It is a peculiar gratification to me to state, in this first page, that during the whole of these researches I have enjoyed the inestimable advantage of the able, skilful, and untiring co-operation of Mr. Henry Smith, of Torrington Square.

3. It is nearly twenty years since I observed the phenomenon which first directed my attention to *The Spinal System*, or, as I now propose to designate it, *The Diastaltic Nervous System*. My attention to the subject

has, ever since, been almost incessant; and I think I have, during the period which has intervened, devoted no less than 25,000 hours to its experimental and clinical investigation, viewing it in its relations to *Anatomy, Physiology,—DIAGNOSIS,—Pathology, and Therapeutics*. Indeed, if I may include the hours devoted to the study of the Diseases of the Nervous System, in practice, I think I may nearly double this number; and I can sincerely affirm that the experience of each day has added to its value in my estimation, both in itself and in its practical applications. The physiology of the spinal system is, in fact, the *Key* to the pathology and diagnosis of the *Class* of the Diseases of the Nervous System.

4. It is by such persevering toil only that new and great truths in medicine are detected and elaborated, and error avoided.

5. In 1831, I read a paper on the Circulation of the Blood, as observed principally in the Batrachia, before the Royal Society. Besides the different *Schemes* of the minute arteries and minute veins, seen in the several seats of the *systemic* and *pneumonic* circulation, that paper contained the discovery and the first enunciation of a distinct series of vessels or blood-channels, occupying the spaces intermediate between the last branches of the arteries and the first roots of the veins, channels which I then designated the ‘true capillaries.’ This designation has been justly criticised by Dr. Voigt, the pupil of the celebrated Prof. Berres, of Vienna, the anatomist to whom we are indebted for the greater part of our knowledge of the different forms of these vessels, which he proposes to call, from their position between the arteries and the veins, the “*Systema Vasorum Intermedium*.”

6. The subjoined extract from the Dissertation of Dr. Voigt will be perused with interest by my friendly reader*.

* “Recte dicit Marshall Hall, quod hujus provinciæ vascula ex integro distincta sint a vasis arteriosis et venosis minutis; exacte describit et depingit, si nobis refert: arteriam

7. From the fact that it is in these vessels or channels that *all* the *changes* in the blood are effected, whether in the systemic or the pneumatic circulation, I have more recently thought that the designation *methæmatus* blood-channels, or more briefly, *methæmata*, would be the most appropriate. The veins, heart, and arteries are mere *machinery* for conveying the blood to and from these *methæmata*, in which, in reality, *all* the *purposes* and *objects* of the circulation are effected.

8. But to return from this digression—It was during the preparation of that paper that I was struck with the occurrence of the phenomenon to which I have adverted, the first of the series which I have since designated ‘reflex actions.’

9. My friend Mr. Henry Smith and myself, had, on a memorable day, observed and traced the pneumatic circulation in the *Triton*. We then removed the head, and divided the senseless body of the animal into three portions, anterior extremities, posterior extremities, and tail :

10. *On irritating the separated tail with the point of a probe or the forceps, it was observed to move and become contorted into varied forms !*

11. On irritating the anterior or posterior extremity in the same manner,

in venam non immediate transire, sed intercedente reticulo vasculoso, illorumque retium vascula nec per divisionem minora, nec per unionem majora fieri, sed eundem fere diametrum servare et globulos sanguinis vehere, qui microscopii ope perfecte oculis pateant.

“ Non recte vero retinet denominationem ‘ *Vera vascula capillaria.*’ ”

“ Summo jure Præceptor meus illam vasorum aream quæ ultimis arteriis et primis venis interposita est ” “ nomine *Systematis vasorum intermedii* designavit.”

“ Marshall Hall *primus tempore* est, qui pronunciavit, in hac hucusque *vasorum capillarium* nomine comprehensa vasorum sanguineorum provincia *distinctionem* faciendam esse: in *arterias minutas, vera vasa capillaria* et *venas minutas*; nam vera vasa capillaria, a vasis arteriosis et venosis parvis, certis et definitis characteribus differunt.”

“ Josephus Berres ea quæ sequuntur, jam publicaturus, adhuc ignorabat illa, quæ Marshall Hall, in opere supra laudato ” “ palam fecerat.”—C. A. Voigt, *de Systemate Vasorum Intermedio*; 1840; p. 17, 29.

these also moved, being withdrawn and made to approach the adjacent portion of the trunk of the animal.

12. These phenomena are beautifully represented in a drawing by my friend Mr. Simpson, of Stamford, and in an engraving by Mr. Bagg.

13. Other similar phenomena were speedily observed; and I was gradually led on to the development of the spinal or diastaltic system.

14. In the following pages, I propose, as I have stated, to give a brief *Synopsis* of this system, for the benefit of those members of my profession, whose time is too much occupied to admit of reading longer works; and I must suppose my 'Memoirs,' and especially my last or 'New Memoir,' to be in the hands of all who wish to enter fully into this inquiry. But before I proceed with my detail, I must take this early opportunity of explaining several new terms which I have thought it necessary to introduce, in order that my views may be fully and unequivocally expressed, and all but the most wilful misrepresentation prevented.

§ II.—*New Terms proposed.*

15. On analysing the facts which have been detailed, I observed that the following anatomical relations are essential:

1. A nerve leading *from* the point or part irritated, *to* and *into* the spinal marrow;
2. The spinal marrow *itself*; and
3. A nerve, or nerves, passing *out of* or *from* the spinal marrow,—*all in essential relation or connection with each other.*

16. On these anatomical facts I have ventured to institute a new nomenclature, descriptive of what I have hitherto designated *The Spinal System*, and expressive of these essential points. The term peristaltic (from *περι*

and *στέλλω*, to contract) is familiar to us all. It may be justly extended to all the movements of the interior organs, as the heart, the stomach, the large and small intestines, the uterus, &c. These movements, it is well known, are independent of the spinal marrow. But it has been shown that a series of experimental phenomena, and it will be shown hereafter that a series of important functions, are effected by means of the series of nerves in essential connection with the spinal marrow, to which I have adverted. The action or act is performed *through* the spinal marrow as its essential centre. I propose to designate the phenomena by the term *dia-staltic*.

17. The spinal system may henceforth be designated—*The Diastaltic Nervous System*, a designation which will have the advantage of including this system in the invertebrate as well as the vertebrate tribes of animals. This system embraces a peculiar anatomy, physiology, pathology, and therapeutics.

18. Perhaps the only *purely* diastaltic function is *Respiration*; and this is variously modified by volition and influenced by emotion. But there are many other functions which partake of *both* the diastaltic and peristaltic character. Such are the functions of the immediate conduits of ingestion and of egestion;—the œsophagus, the rectum, the uterus. These functions are *dia-* and *peri-* staltic.

19. How much there is in these terms calculated to excite new and accurate inquiry! How much to refute injurious and calumnious criticism! I have hitherto spoken of the *mode* and *course* of the diastaltic actions and functions. But I shall immediately proceed to show that the *Principle* of action in the diastaltic nervous system is as special and peculiar as its direction. This principle I long ago demonstrated to be the *vis nervosa* of Haller, the '*excitabilité*' of M. Flourens, acting in newly discovered, diastaltic, forms. Now, the term 'reflex' may have been

vaguely used by Prochaska; but the *full* and *distinct* idea of a diastaltic action of the *vis nervosa* had occurred to no one.

20. We are much in need of other terms still, to aid us in this investigation. The terms incident excitor and reflex motor have been used to designate those nerves whose influence proceeds *to* and *from* the spinal marrow. But they have never appeared to me satisfactory, and I have long wished for others more expressive and explicit. The following compounds of *óδος*, a way, have appeared to competent judges very appropriate to our subject: esodic ($\epsilon\sigma\omega$) will express the action *into*; exodic ($\epsilon\xi\omega$), the action *out of*; anodic ($αν\omega$) will express the *ascending*, cathodic ($κατα$) the *descending*, course of action; pollodic ($\piολυς$) and panthodic ($πας$) will express the facts, on which I shall shortly have to dwell at considerable length, of the action of the *vis nervosa* from each *one* point of the diastaltic system, in *many* or even *all* directions, to *every* other.

21. Many important facts, many important truths, will be conveyed to the mind at once by these simple terms. Their root is already familiar to us in the word periodic; and several derivations from it have already been employed, in the science of his creation, by the illustrious Faraday. It must be distinctly understood that they are all to be restricted to the anatomy, physiology, pathology, and therapeutics, of the diastaltic nervous system, in which they express the modes of action of the *vis nervosa*, distinctly from and exclusive of all other influences whatever, as sensation, volition, emotion, &c.

22. According to the Roman critic—

“ Si forte necesse est
Indiciis monstrare recentibus abdita rerum,
Fingere cinctutis non exaudita Cethegis
Continget; dabiturque licentia sumpta pudenter.”

§ III.—*Subsequent Experiments.*

I may now proceed with my detail :

23. If, in the severed head of the frog, the toad, the eel, the snake,—the kitten, the puppy, the young rabbit, &c. we touch the eye-lid, the eye-lash, or the conjunctiva, the eye is immediately closed. The same event occurs in the horse stunned to insensibility by the blow of the pole-axe.

24. If, in the decapitated trunk of these animals, we irritate a toe or other part of the foot of the anterior or posterior extremity, this extremity is immediately withdrawn ; if we irritate the tail, or the integuments near the sphincter ani, still greater movements are produced.

25. If the brain merely be removed, in a very young animal, all these phenomena are still observed.

26. The same effects are produced by irritating the dura mater within the cranium, and other interior membranes and tissues—a fact which throws a beam of light on some pathological events.

27. By any of these irritations, an act of inspiration, if respiration were previously suspended, is especially apt to be induced.

28. Each irritation of a cutaneous or mucous surface appears to induce a peculiar, *special*, and definite movement. If in the very young kitten, deprived of cerebrum and cerebellum, the foot be irritated, it is retracted ; if a finger be introduced between the lips, an act of suction is excited ; if a soft substance, as milk, be inserted into the pharynx, an act of deglutition is attempted ; if the border of the rectum be irritated, the sphincter is contracted. The eye-lash, the meatus of the ear, and the tufts of hair between the toes, are peculiarly excitor.

29. *Similar* phenomena are observed in the anencephalous fœtus,

in the early stage of asphyxia in young animals, and in the anæsthesia induced by chloroform.

30. In the case of perfect paraplegia in the human subject, when sensibility is absolutely extinct, and voluntary movements totally abolished, diastaltic actions are excited on the application of appropriate irritants, such as tickling, a puncture, a pinch, or sudden heat or cold; of all which the patient is unconscious.

§ IV.—*Previous Experiments of Redi, Whytt, &c.*

31. Perfectly similar experiments had been made long ago, by Redi, Whytt, Legallois, Blane, &c. This was fully stated by me in my first publication on the subject (see Memoir I, § 107, 129, &c.). Whytt had even asserted the necessity for the presence of the spinal marrow; and Blane had stated that sensation is excluded. What then? Did those observations lead to any result?—to any detection of the motor Principle involved?—to any application to Anatomy, Physiology,—Diagnosis,—Pathology, Therapeutics,—or Obstetrics? No! Not one tittle of all this was accomplished by any one.

32. In making this assertion, I include Unzer and Prochaska, of whom so much has been calumniously written in this country.

33. Whytt speaks of all the phenomena in question as dependent on the *soul*.

34. Unzer asserts that the spinal marrow is merely a '*thick chord of nerves*,'*—(a view which *excludes* the *idea* even of a really reflex or dia-

* "Das Gehirn ist auch der Ursprung aller Nerven, als welche an sich nichts anders als Fortsetzungen des Gehirnmarks sind, die sich theils unmittelbar von ihm, in kleinern Bündeln absondern, und Nerven des Haupts heissen, theils aus einem dicken Strange desselben, der durch den Rückgrat hinabsteigt, und das Rückenmark genennt wird, ausgehen, und sich im Körper vertheilen."—*Erste Gründe einer Physiologie, &c.* von D. J. A. Unzer p. 14, § 12.

staltic action absolutely)—and may be fairly supposed to speak through his pupil, Prochaska. Now the latter author describes diastaltic actions as ‘*impressionum sensoriarum in motorias reflectio* ;’ and, so far from even entertaining the idea of a *dia-staltic function* or *System*, confounds the effects of volition and emotion, and the action of the heart, stomach, and intestines, with actions really and truly diastaltic.

35. I will only add, in conclusion of these brief remarks, the expression of my regret, that any of my professional brethren should be found, of minds so ignoble as to persist in the injustice which has been so long, although vainly, attempted in this matter—continually immolating, during the whole course of nearly twenty years, *truth* on the altar of misrepresentation and detraction*.

§ V.—*The Vis Nervosa of Haller ; its Catastaltic Law of Action.*

Figure 2.

36. The *Vis Nervosa*, that power in the spinal marrow and muscular nerves, by means of which, if their tissues be irritated, muscular contraction follows, was supposed by Haller, by Bichat, by Prof. J. Müller, and, I believe, by all physiologists, to act in *one* direction only—*from above downwards*. Its action was supposed to be *cata-staltic* only.

37. As long as this view prevailed, this motor power had, and could have, no application to physiology. It was presented to us as a mere experimental fact, or, at the utmost, in its relation to pathology.

38. It was, like the facts noticed in § IV, sterile and without utility. Now the existence of a distinct and energetic motor power in the animal frame, without utility in the animal œconomy, would be a perfect incongruity, and contrary to every thing observed in creation.

* See Dr. Forbes's Review ; Dr. Todd's Cyclopædia ; &c. &c.

39. By a series of oft-repeated experiments, I have demonstrated other *Laws* of action of the *vis nervosa*, and especially *one* which may be designated *dia-staltic*.

40. By this discovery, I have been enabled to prove the identity of the motor power in these experiments of Haller and in the experiments of Redi and of Whytt, and, disentangling the maze, to show that that double series of experiments is *not* without its application in physiology; that the latter have, in fact, their prototypes in all the acts of ingestion and of egestion in the animal œconomy, and in some instances of pathological and therapeutic actions; and the former, in certain cases of pathology. It is the first real step in the philosophy of involuntary motions.

§ VI.—*The Diastaltic Law of Action of the Vis Nervosa:*
its Demonstration.

Figure 3.

41. If the spinal marrow, in the decapitated tortoise or turtle, be denuded and irritated by the point of a needle, or the galvanic current, *both* anterior and posterior extremities are moved. The *same* irritation, applied to one and the *same* point of this nervous centre, produces *all* these movements.

42. If, instead of irritating a point of the spinal marrow itself, we denude and irritate a lateral spinal nerve,—the same results, the same movements of *both* pairs of extremities are observed.

43. In the first experiment, it is the *vis nervosa* of Haller which acts on the *posterior* extremities. This is the general view. Are the similar and synchronous movement of the *anterior* extremities, and the similar movements of *both* anterior and posterior extremities in the second experiment, of *different* origin? But if the integument be irritated, the

same movements still take place; and this is one of the cases of reflex or diastaltic action,

44. Lastly, if we so irritate the border of the eye-lid, the eye-lids close; or if we touch the border of the larynx, or of the sphincter ani, these orifices are closed. But these are *Functions*.

45. I repeated this experimental demonstration, on the tortoise, before M. Serres, and my friend M. Gariel, in Paris, in 1837. The following is an extract from M. Gariel's account of it:

46. "La tête étant séparée du tronc, on mit la moëlle épinière à nu au niveau de la région dorsale, par conséquent au dessous du niveau de la naissance des nerfs qui se rendent aux extrémités supérieures; lorsqu'on la toucha avec un stylet, ou qu'on l'excita au moyen du galvanisme, on produisit des mouvemens de tous les membres et de la queue.

47. "Ayant mis à découvert un nerf intercostal, après avoir enlevé les organes contenus dans l'intérieur de la carapace, on le stimula par les mêmes moyens et l'on obtint le même résultat.*"

48. Such I believe to be the *Demonstration* of the diastaltic action, and such the application to physiology, of the *vis nervosa* of Haller†. Previously a sterile experimental fact, this principle of action has now taken its place as the dynamic force presiding over the large *Class* of the *functions* of ingestion and of egestion in the animal œconomy.

49. It appears to me that the anastaltic and the diastaltic actions, in these experiments, are slower and more combined than the merely catastaltic. There is a similar difference between physiological acts, which are all diastaltic, and those pathological movements which are catastaltic.

* See 'The Diseases and Derangements of the Nervous System,' p. 45.

† See Memoir II, § 15 —; New Memoir, § 95 —.

§ VII.—*Panthodic Law of Action of the Vis Nervosa.*

Figure 4.

50. Nor is the action of the *vis nervosa*, under these circumstances, merely diastaltic. It frequently occurs that, instead of such an event, there are diastaltic actions in *many* or *all* directions.

51. *Exp.*—If a frog be decapitated, and a toe of one anterior extremity be irritated with the forceps, this and all the other limbs are moved. There are therefore a reflex action, and actions in the various directions across the spinal marrow, and downwards along this nervous centre, both directly and obliquely, to both inferior extremities.

52. *Exp.*—If a toe of an inferior extremity be irritated, the phenomena are still the same: reflex, across, and upwards, both directly and obliquely, to both anterior extremities.

53. In the first experiment, the action of the motor power is esodic in the nerves, and variously reflex, diastaltic, and *cata*-staltic in the spinal marrow; in the second, it is *ana*-staltic. And, so far, the action might be designated as pollodic. But I use the term panthodic in a very emphatic sense: I believe that no spot of the diastaltic system can be excited without telling upon *every* other. Inspiration, partially suspended, is excited by irritation on *any* part of the external surface. The application of cold water on the face not only excites inspiration, but deglutition, micturition, contraction of the uterus, &c. The entire system is in a state of static tension, *each* part being in strict relation with *every* other; this becomes dynamic force on the application of a stimulus.

54. Sometimes there are *combined* and *concatinated* actions; and wherever the excitation may be applied, there may be a leap or jump.

55. It must be observed that in all these cases the *nerves* are esodic

and exodic ; but of what takes place *within* the structure of the spinal marrow, on which might well be inscribed the word—*mystery*, we are still utterly ignorant ; we only know that the result of irritation in such a case is, not only variously diastaltic, but panthodic.

§ VIII.—*Diastaltic Actions Special, resembling Design.*

56. Diastaltic actions are sometimes so combined, and, as it were, concatenated, as nearly to resemble acts of volition.

57. If a toe of the posterior extremity in the frog be irritated, the limb is flexed at the first, second, and third articulations, and drawn close to the body of the animal, by those *combined* movements.

58. But frequently, besides these movements of flexion, sudden movements of extension take place ; sometimes of one extremity, but sometimes also of both. These *concatenated* movements may issue in a jump or leap even. It is only by observing that, when these movements have ceased, no further movements—*no spontaneous movements*—occur, and by a certain peculiarity, readily detectible by those who have performed a lengthened series of experiments, that their real nature is detected.

59. Movements in *all* directions from any *one* point of the system, continued movements, and concatenated movements, are observed under other circumstances.

60. *Exp.*—If a kitten be reduced to a state of asphyxia, and the nostril, the ear, a toe of the anterior or posterior extremity, the tail, or the sphincter ani, be irritated, an act of inspiration is excited.

61. If, under various circumstances, we dash cold water in the face of the human patient, an act of inspiration, or of deglutition, or an act of contraction and expulsion in the rectum, the bladder, or the uterus, may be excited.

62. Each and every part of the spinal system is bound in a bond of action with each and every other part of that system.

63. The modes of action hitherto described have been induced by excitants applied to the cutaneous surface. And, indeed, as I long ago observed (and before Prof. Volkmann*), it is the fine *origins* of the incident or esodic nerves, spread on the cutaneous or membranous tissues, which are the most excitable.

64. Some parts of the cutaneous surface are more excitable than the rest. This extraordinary excitability is especially observed in the toes and near the sphincter ani, in the frog; and within the ear, in the eye-lid, in the sole of the foot, in the young kitten and puppy. If the integument near the sphincter ani, in the frog, be irritated, a movement of the posterior extremities, *apparently* designed to remove that irritation, occurs.

65. The final cause of all this is obvious. If an object be placed in the hand of a sleeping infant, it is grasped pretty firmly, by a mere diastaltic action. Such action appears designed to strengthen and aid, and to cooperate with, volition. If it were otherwise, each act of volition would be opposed and thwarted by diastaltic actions, and the objects of volition might be frustrated.

66. The act of inspiration presents us with the most marked example of combined action, including that of the nostril, the larynx, the intercostal muscles, and the diaphragm. This act also includes a concatenated action; for the act of inspiration is essentially *linked* with the act of expiration. This is most obvious in the case of sneezing. But it is not less so, to the attentive observer, in ordinary respiration, in which there is a sort of continued equilibrium of action. To this point I shall have to revert hereafter.

* Memoir II, § 21; New Memoir, § 109, 110.

§ IX.—*Volition and Emotion.*

67. Before I quit the subject of movements, I must advert, in a few words, to those movements which follow an act of volition, and a state of emotion.

68. The former acts in *one* direction only, or from above, or *from* the nervous centre, *to* the muscles of voluntary motion.

69. Emotion acts from above downwards too; but it acts in *two*, *three*, or *more* directions: first, to muscles of voluntary and involuntary motion; and secondly, to the organs of the peristaltic and secretory systems.

70. The *same* nerve or nervous fibre does *not* act in *all* these cases. The same nerve or kind of nerve does not lead to a voluntary or an involuntary muscle, or influence the hand, the heart, the intestine, *and* the kidney.

71. Much has been said, but very little is really known, on the subject of a distinct system of nervous *fibres* in the different portions of the nervous system. I have never expressed myself on this point with the confidence injuriously ascribed to me*. The case is one in which true philosophy teaches us to speak with diffidence, whilst we avoid all derogatory cavilling and criticism—not less derogatory to the profession than to individuals.

72. I beg to refer my reader to my New Memoir, § 150, 370, &c. for my own mode of viewing this interesting question. I will merely add, that, in hemiplegia, the arm paralysed to volition is moved by emotion; and that the heart unaffectible by volition, is made to palpitate by emotion. Is the anatomy *identical* in one case, although *distinct* in the other?

* See particularly Memoir II, § 29—39; the New Memoir, § 144—151, and 370; and § 73, on the succeeding page.

73. 'The only *experiment* which throws any light upon this subject is one originally performed by Dr. van Deen, and repeated by Dr. Stilling: one half of the spinal marrow is divided above, and the other below, the origin of the brachial nerves, for example;—the *whole*, therefore, of this organ is divided,—yet sensation and voluntary motion remain! There is, therefore, no continuous rectilinear course of nervous fibre from the brain to the extremities!'

74. This paragraph is quoted from the 'New Memoir,' § 370, to prove the truth of the observation made § 71. I am opinion, however, that the really voluntary movements of the anterior extremity unimplicated in the experiment, induced friction between the other limbs and the table, and reflex diastaltic movements, which were mistaken for sensation and voluntary motion. A similar error has probably been committed in other instances.

75. Repeated acts of volition fatigue. The normal acts of the spinal or diastaltic system are continued through life without fatigue. Respiration is unattended by this effect; but if we *think* intently of our breathing, the acts of respiration become acts of volition, and soon issue in oppression and fatigue. The same position long retained during sleep refreshes, which, if so retained during the absence of sleep, would fatigue extremely.

76. Hence the cerebral system requires to be renewed or restored by *sleep*; the diastaltic system never sleeps.

77. The principle and character of the action are thus widely different in the two systems. Is the anatomy the same?

SECTION II.

CONDITION OF THE VIS NERVOSA.

§ I.—*Condition of the Vis Nervosa; Static and Dynamic.*

78. THE cerebrum and cerebellum are insensible and *in-excitor* or *a-staltic*, on being punctured or lacerated, whilst their principle of action, the $\psi\nu\chi\eta$, is *spontaneous* in its motor influences.

79. The spinal marrow, on the contrary, is essentially *excitor*, requiring the application and repetition of a stimulus for the development of each and every movement.

80. The natural condition of the spinal marrow is one of *inaction*, or of *static equilibrium*. It is by appropriate and successive stimuli that its *dynamic force* is made effective and manifest.

81. This statement is true in every condition of the spinal marrow. Even when its excitability is extreme, under the influence of strychnine, freedom from stimulus is freedom from all motor action.

82. Still more is this the case in the state of diminished excitability from *shock*, from chloroform, &c.

83. After the application of a stimulus and the phenomena of *dynamic force*, the spinal marrow again resumes its condition of *static equilibrium*, but with reduced excitability. The action of each stimulus is followed by this effect, and each second stimulus is accordingly less effective than the former one. The excitability is, on the other hand, restored by

repose. And thus the static equilibrium and the dynamic force bear a certain relation to each other.

84. A frog, affected by shock, or placed under the influence of chloroform, may be deprived of voluntary movement, respiratory movements, and reflex actions, the circulation being also almost extinct. If it be now left at rest, respiratory movements return. If it be excited, they again cease. And thus repeatedly. The same observation applies to all other movements. Quiet is the restorer, excitement the exhauster, of the motor energies.

§ II.—*The Spinal Marrow susceptible of augmented Excitability.*

85. The degree of Excitability of the spinal marrow is, in general terms, (like Irritability of the muscular fibre), inversely as the degree of Activity or of Stimulus.

86. Augmented or restored during sleep, it is diminished during each day, by every act of volition, every act of the respiration, and by each meal.

87. But the excitability of the spinal marrow admits of intense augmentation and extreme diminution by therapeutic agents. That of the nerve admits of no such augmentation.

88. *Exp.*—The tenth part of a grain of the acetate of strychnine dissolved in distilled water, and applied over the cutaneous surface of the frog, induces the most extreme excitability, or hypererethism. The slightest stimulus induces violent tetanoid spasm. Meantime, the circulation, in the intervals of such spasms, remains unimpaired.

89. *Exp.*—On the other hand, if ten drops of chloroform be dropped on a bit of sponge and attached to the upper part of a tumbler, and this be inverted on a plate of glass, so as to enclose a frog, this animal first

ceases from voluntary movements, then loses its excitability, and, lastly, its circulation.

90. Undue excitability is the usual effect of teething, of irritated esodic nerves in general, and especially in the case of a wounded nerve, as in tetanus.

91. The usual immediate effect of a convulsive seizure is augmented excitability; and therefore one seizure frequently succeeds to another. The remoter effect is diminished excitability, and the patient is frequently secure from other attacks until the excitability is slowly restored.

92. Indolence allows the excitability to become morbidly great; activity diminishes its degree or intensity. Hence the importance, in such cases, of restraining the excitability by daily exercise, limited only by approaching fatigue.

§ III.—*Relation of Irritability to the Cerebrum and Spinal Marrow.*

93. We are naturally led, by the consideration given in the last section, to the subject of the present one. Every act of an organ is followed by diminished energy or power. This is not only true of the nervous tissue, but of the muscular fibre. Each contraction of a muscle is followed by a diminution of the irritability of the muscular fibre. If, on the contrary, all stimulus be removed, the irritability exists in its maximum degree.

94. But, for the perfect state of the muscular irritability, it is essential that the muscle should have remained in connection, through the nerves, with the spinal marrow. *The spinal marrow is, so far, the source of muscular irritability.*

95. If, in experiment or disease, the influence of the brain, that is,

of volition, be withdrawn from a muscle, its irritability becomes greater, comparatively, than that of the similar muscles. In cerebral paralysis, or that paralysis in which the influence of the cerebrum is removed from a limb, the muscles of that limb are more irritable, *tested* by the *mildest* galvanic influence which will produce an obvious effect, than those of the other limb.

96. But if the connection between the spinal marrow and the muscle be severed, either in an experiment or by disease, the irritability of the muscles of the paralysed limb (and the excitability of the severed portion of nerve) is less than that of the healthy limb.

97. These conclusions are founded upon a vast number of experiments, most carefully made and observed.

98. The fact affords a *Diagnosis* between cerebral and spinal paralysis, or between the cases of paralysis in which the influence of the *cerebrum*, or of the *spinal marrow*, is *severed*, respectively—a diagnosis frequently of great importance*.

§ IV.—*Relation of Excitability and Irritability to Stimuli.*

99. The chief stimulants of the animal frame are the acts of volition, and, what are in exact proportion to these, heat, food and air. The excitability of the nervous system, and the irritability of the muscular, are inversely proportionate to these stimuli.

100. This *Law* of the *Inverse Ratio* prevails throughout animated nature, and is, perhaps, the most general of all. It was announced by me nearly twenty years ago, in the *Philosophical Transactions*.

* Vide the *Medico-Chirurgical Transactions*, vol. xxii, xxxi; and *The Lancet*, and the *London Journal of Medicine*, for 1849.

101. During activity, the stimuli are all augmented; the excitability and irritability are proportionately diminished. During sleep, the reverse obtains: the stimuli are at their minimum, the excitability and irritability are at their maximum.

102. *Exp.*—Having removed the head of a frog, we separated every part of the animal, leaving only a portion of the spinal marrow in connection with the denuded and separated lumbar nerves, and the lower extremities deprived of integument. We passed a galvanic current through the nerve and limb, until the movements had nearly ceased. We then passed a very mild current equally along both lumbar nerves, excluding the muscles; and then a stronger current equally through the muscles of both limbs, excluding the nerves: we found that the *excitability* of the nerve and the *irritability* of the muscles had been *alike* reduced by the repeated action of the stimulus.

103. A frog, prepared so as to expose the nerve in connection with the muscles, has been designated '*galvanoscopic.*' Galvanism is, in its turn, the *Test* of the excitability of the nervous, and of the irritability of the muscular, fibre. So tested, these properties are found to be greater as we descend in the zoological scale, whilst the quantity of stimulus—food, respiration, temperature—is known to be less, in the same ratio, but inversely.

SECTION III.

THE ANATOMY OF THE DIASTALTIC SYSTEM.

§ I.—*General Observations.*

104. IN treating of the *Anatomy* of the diastaltic system, it is my intention to display, not the results of dissection by the scalpel, with or without the microscope, but of *experiment*,—not mere tissues, but organs and phenomena.

105. The great, the important division of the nervous system, is, into its in-excitor or astaltic, and its excitor and staltic portions. The former embraces the cerebrum and cerebellum, and the olfactory, the optic, and the acoustic nerves; the latter, the tubercula quadrigemina, and the new *Class* of the esodic nerves, the spinal centre, and the exodic nerves.

106. All this is but the expression of fact, the result of experiment and observation, all hypothesis being excluded.

107. Volition is seated in the in-excitor portion of the nervous system. The seat of emotion is so too, but approaches the excitor.

108. Whatever the *precise* limits of the different parts of the nervous system may be, there is no doubt that volition is seated higher in that system than emotion, and emotion than pain.

109. The hemiplegic attack, which severs the influence of volition from the arm, leaves that of emotion on this member entire; and it frequently happens that the patient is a prey, as it were, to uncontrollable laughter or tears.

110. Even when the whole encephalon is removed in an experiment on the rabbit, the sole medulla oblongata excepted, cries, the unequivocal expression of pain, are induced by pinching the foot or the tail severely with the forceps. And as the sense of touch is seated in the cerebrum and the cerebral nerve of touch, so I think there are reasons to believe that the susceptibility to *pain* resides in the *medulla oblongata* and the system of *ganglionic* nerves. These reasons will be given hereafter.

111. In the case of the atrophy or defective development of the brain in idiots, the passions and appetites are frequently developed in proportion as the intellect is defective.

112. Below perception and volition, then, emotion and passion are seated; below these are seated excitability and diastaltic action—the diastaltic system. Evenly with both the latter, we have the peristaltic and secretory system. The influence of emotion is shed over the spinal and the ganglionic systems.

113. There is the same *kind* of evidence for the nerves of each of these systems,—dissection, and experimental fact. No one doubts that the optic is the nerve of sight; as little can any one doubt that the trifacial is an excitor diastaltic nerve; &c. Therefore the rude remark of Prof. Bischoff is the more incomprehensible*.

114. I here introduce tabular views of the Nervous System, and of the Diastaltic System.

* Müller's Archiv. for 1844, p. 125.

Division of the Nervous System.

I. <i>The Cerebral System,</i>	$\left\{ \begin{array}{l} 1. \text{The Cerebrum,} \\ 2. \text{The Cerebellum,} \\ 3. \text{The Nerves of Special Sense,} \\ \quad 1. \text{The Olfactory,} \\ \quad 2. \text{The Optic,} \\ \quad 3. \text{The Acoustic ; \&c.} \end{array} \right.$	$\left. \begin{array}{l} \text{In-excitor, but Motor} \\ \text{through} \\ 1. \text{Volition,} \\ 2. \text{Emotion.} \end{array} \right\}$
II. <i>The Spinal System,</i>	$\left\{ \begin{array}{l} 1. \text{The Tubercula Quadrigemina,} \\ 2. \text{The Medulla Oblongata et Spinalis,} \\ 3. \text{The Esodic Nerves,} \\ \quad 1. \text{The Trifacial,} \\ \quad 2. \text{The Pneumogastric,} \\ \quad 3. \text{The Spinal ;} \\ 4. \text{The Exodic Nerves,} \\ \quad 1. \text{The Facial,} \\ \quad 2. \text{The Pneumogastric,} \\ \quad 3. \text{The Intercostal,} \\ \quad 4. \text{The Diaphragmatic,} \\ \quad 5. \text{The Abdominal,} \\ \quad 6. \text{The Sphincteric ; \&c.} \end{array} \right.$	$\left. \begin{array}{l} \text{Excitor and Diastaltic, through} \\ \text{Stimulus.} \end{array} \right\}$
III. <i>The Ganglionic System,</i>	$\left\{ \begin{array}{l} 1. \text{The Spinal Centre ;} \\ 2. \text{The Intra-Spinal Ganglionic System ;} \\ 3. \text{The Extra-Spinal Ganglionic System ;} \\ 4. \text{The Arterio-Ganglionic System ;} \\ 5. \text{The Intra-Visceral Ganglionic System* .} \end{array} \right.$	$\left. \begin{array}{l} 1. \text{Peristaltic,} \\ 2. \text{Secretory.} \end{array} \right\}$

* This last generalization is the result of the splendid discoveries of Dr. Robert Lee, the most important, in *Anatomy*, of the present century, as the first to display the *intra-visceral ganglia*.

Anatomy of the Diastaltic System.

I. *The Esodic Branches.*

1. *Part of the Optic.*
2. *The Trifacial, arising from—*
 1. *The Eye-lashes.*
 2. *The Alæ Nasi.*
 3. *The Nostril.*
 4. *The Fauces.*
 5. *The Face.*
3. *The Pneumogastric, from—*
 1. *The Pharynx.*
 2. *The Larynx.*
 3. *The Bronchia.*
 5. *The Cardia,—Kidney, and Liver.*
4. *The Glosso-Pharyngeal.*
5. *The Posterior Spinal, arising from—*
 1. *The General Surface.*
 2. *The Glans Penis vel Clitoridis.*
 3. *The Anus.*
 4. *The Cervix Vesicæ.*
 5. *The Cervix Uteri.*

II. III. *The Ezodic Branches.*

- The Tubercula, the True Medulla Oblongata and Spinalis, the Centre of the System.
1. *Part of the Third to the Iris.*
 2. *The Trochlearis* } *Oculi.*
 3. *The Abducens* }
 4. *The Minor portion of the Fifth.*
 5. *The Facial, distributed to*
 1. *The Orbicularis.*
 2. *The Levator Alæ Nasi.*
 6. *The Pneumogastric or its Accessory—*
 1. *The Pharyngeal.*
 2. *The Œsophageal and Cardiac.*
 3. *The Laryngeal.*
 4. *The Bronchial, &c.*
 7. *The Myo-glossal.*
 8. *The Spinal Accessory.*
 9. *The Spinal, distributed to the*
 1. *Diaphragm, and to*
 2. *The Intercostal and* } *Muscles*
 3. *The Abdominal* }
 10. *The Sacral, distributed to*
 1. *The Sphincters.*
 2. *The Expulsors, the Ejaculators, the Fallopian Tubes, the Uterus, &c.*

115. I have often thought that it would be interesting to adopt the following method of *Synthesis* or building up the nervous system :

116. Let the cerebral, the spinal, and the ganglionic portions of this system be severally drawn on transparent paper; and let them then be superposed on each other. From being viewed separately and distinctly, they will come to be viewed together as a whole.

117. An advantage will arise from this procedure, not anticipated, perhaps, at first. The same nerve—for instance, the trifacial and the pneumogastric—may occur in several of the drawings. It will hence be apparent that these nerves have more than one function, and belong to more than one division of the nervous system.

118. The trifacial probably belongs to all three divisions of the nervous system, being the nerve of the sense of touch, the excitor diastaltic nerve of the face, and the secretory of the head. All this is proved *physiologically* by observing the loss of function, the effect of its destruction in disease, or division in experiment: the sense of touch is extinct; the excitability of the conjunctiva, of the Schneiderian membrane, &c. is lost; and the eye and the tissues of the face become atrophied.

119. Before I conclude these general observations, I have an additional remark to make :

120. The late Sir Charles Bell treated of what he designated a “Nervous Circle,” defining it thus :

121. “Between the brain and the muscle there is a circle of nerves; one nerve conveys the influence of the brain to the muscle, another gives the sense of the condition of the muscle to the brain.”

122. I think this view an error. I believe we have no consciousness of the condition of individual muscles, or sets of muscles, as we have no power of acting on such muscles. The sense, sometimes denominated the muscular sense, is, I believe, not in the muscle, nor in any sentient mus-

cular nerve, but in the nerve of touch, or of vision ; and volition is not directed to any muscle, or set of muscles, but to the aim, object, and purpose of their contraction. We are guided in our voluntary actions, not by muscular sense or nerve, but by the sense of touch or of vision, by the *cutaneous* or the *optic* nerves.

123. There is a class of phenomena in some cases of paralysis, which, I think, throw a ray of light on this subject. If there be loss of sensation in the fingers, the patient lets any object held by them escape and fall, unless the eye be continually directed towards them, to regulate the force of muscular contraction. If a patient have lost the power of sensation in the feet, he cannot walk in the dark ; the eye is essential to the due action of the muscles of the lower extremities. I have a patient afflicted with partial paraplegia, who has no power of *balancing* himself without the aid of the eye. We have only to consult our own consciousness, to be aware that “ the nervous circle” is not between muscle and muscle, but between one sentient nerve, whether of touch or of sight, and another. The sensation does not ascend from the muscle, nor does volition descend to it ; but the former arises from a nerve of sense—of special sense—and the latter is directed to an aim or purpose, in attaining which the former is the *guide*.”

§ 1.—*Analysis of the Nervous System.*

Figure 5.

124. I need scarcely advert to the long-adopted division of the nervous system into the cerebro-spinal and ganglionic, or to the division proposed by myself into cerebral, spinal, and ganglionic.

125. It will appear presumptuous, no doubt, if I state that I have, in

this Inquiry, discovered *the* spinal marrow. But I believe it to be not the less true, that, as distinguished from the supposed spinal chord of cerebral nerves, and from the spinal connections of the ganglionic system, the real and true spinal marrow remained undetected. And yet the distinction between the mis-named cerebro-spinal and the ganglionic systems is not more absolute than that between the cerebral and the spinal or diastaltic. Thus—

126. *Exp.*—If we take a vigorous frog and remove, first, the cerebrum, and then all the viscera—that is, the *centre* of the cerebral system and the very *seat* of the ganglionic, *the Diastaltic System still remains!*—the animal is absolutely motionless in regard to *spontaneous* motion; but if excited by the point of a probe, or the forceps, it moves every limb, and sometimes even performs a combined action, such as a leap or jump, whilst partial movements of respiration may continue: if the eye be touched, it is retracted; if the toe of either the anterior or posterior extremity be irritated, it is retracted in its turn—an effect frequently followed by other movements, and attended by a movement of inspiration if this had ceased.

127. We have, in this experiment, the *Analysis* of the Nervous System, and the distinct isolation of the Spinal or Diastaltic System—for the first time.

128. There is another mode of displaying the diastaltic system, distinctly from the other parts of the nervous system. This is effected by the administration of *strychnine*. The scalpel itself could not more evidently display an anatomical structure.

129. *Exp.*—Let the twentieth part of a grain of the acetate of strychnine be dissolved in two or three drops of water, and be spread over the back of a frog: in a short time, on the application of an excitant, the animal makes a croak and passes into a state of tetanoid spasm for several seconds. The cerebral system and the circulation in the web are alike

unaffected in the absence of spasm ; the spinal or diastaltic system *alone* is under the influence of this extraordinary agent.

130. The nervous system has again been subjected to analysis : the diastaltic system has again been isolated from the rest.

131. *Exp.*—These two modes of proceeding may be combined : we may first divide the spinal marrow near the occiput ; then affect the frog with strychnine, and, having observed the persistence of the circulation, remove all the viscera. We have then the spinal system both isolated by the scalpel, and singled out, as it were, by the strychnine.

132. In this manner we may be said to have analysed the contents of the spinal canal, and, of the three elements of those contents, to have discovered one, and that an unsuspected one. The centre of the cerebral system, the intra-spinal connections of the ganglionic system, being removed, one element remains—the diastaltic system.

133. In an experiment detailed at p. 138 of my *Essay on the Circulation*, I destroyed, at different intervals, the whole cerebrum, cerebellum, and spinal marrow, in a frog, preserving the circulation in the web and in the lung, and doubtless in the mesentery, in connection with the ganglionic system only. In this case the peristaltic system remained alone.

134. At p. 122, an experiment is detailed in which the viscera were actually removed entirely, the pneumonic circulation, a function of the ganglionic system, still remaining, in a slight degree, for a short period.

§ II.—*Analysis of the Diastaltic Nervous System.*

Figure 6.

135. Having *analysed* the general nervous system, and resolved it into the psychic or cerebral, the diastaltic or spinal, and the peristaltic or

ganglionic, I now proceed to the further analysis of the second or diastaltic system.

136. *Exp.*—I took a frog, removed the brain, and divided the animal into three portions, preserving the eyes and the anterior and posterior extremities, in connection with the corresponding portions of the spinal marrow. The reflex or diastaltic actions were annihilated by *any one* of *three* manœuvres :

137. First; by removing the integuments from the point of the extremity irritated :

138. Secondly; by dividing the brachial or the lumbar or femoral nerve leading to the point irritated : and

139. Thirdly; by removing the attached portion of the spinal marrow.

140. In each of these proceedings, a part of the diastaltic nervous *arc* is withdrawn, and the perfect arc is essential to the diastaltic action. In the *first*, the fine *origins* of the esodic nerve was removed; in the *second*, both the esodic and exodic nerves were severed in their mingled course; in the *third*, the key-stone, as it were, of the arc was destroyed.

141. A further analytical experiment of great interest might be added. If *either* the posterior or esodic, or the anterior or exodic, root, be divided within the spinal canal, all diastaltic action must cease, from the want of the esodic and exodic portion of the reflex or diastaltic arc, respectively.

142. There is a proof of a positive kind of the diastaltic function of a lumbar nerve. Let a frog be decapitated and eviscerated, and let the tissues be removed from behind the lumbar nerves, and let the pelvis be divided, as in *figure 7*. Every part of the animal is removed, except the lower portion of the spinal marrow, still in connection, by means of the denuded and separated lumbar nerves, with the posterior extremities :

143. On irritating a toe, on which the integuments exist still, there is a distinct reflex or diastaltic action. Now the influence which has induced

this effect must have been anodic and cathodic in one and the same lumbar nerve. The other limb is also moved, when the frog is vigorous, by diastaltic action.

§ III.—*The Spinal Marrow.*

144. The first opinion respecting the spinal marrow was that still retained by Unzer (§ 34)—that it is a mere chord of cerebral nerves. The cerebrum and spinal marrow are still designated the cerebro-spinal axis, as being the common centre of the cerebral system.

145. Legallois treats of the spinal marrow vaguely, as possessing the “prerogative” of being the seat of *sensation*, and, at the same time, of the *life* of the trunk, and of its regions respectively. The former opinion is an error; the latter, unconsciously on the part of this admirable author, sets forth its influence as the centre of the ganglionic system.

146. M. Flourens was the first clearly to distinguish between the cerebrum and the spinal marrow as in-excitor and excitor—a distinction of the utmost moment in physiology and pathology, as in Diagnosis.

147. Legallois first singled out the medulla oblongata in its important and essential connection with respiration.

148. The next step in the progress of neurological science was that suggested by Walker, taken by Sir C. Bell, and confirmed by Prof. J. Müller. Sir C. Bell was of opinion that the posterior columns of the spinal marrow and the posterior roots of the spinal nerves are destined for *sensation*, whilst the anterior columns and roots are subservient to motion.

149. Legallois first called the attention of physiologists to the distinct influence of distinct *segments* of the spinal marrow over the corresponding segments of the trunk. Mr. Mayo and others have also taken this view of the subject.

150. Such was the condition of our knowledge of the anatomy of the nervous system when I entered on its investigation, in 1830—an investigation which led to an entire distinction of the spinal system from the cerebral and the ganglionic, distinct at least in its application to physiology and pathology.

151. It was during this investigation that I discovered a *special nervous Arc*, consisting of an esodic and anastaltic nerve, *essentially linked* with a special portion of the spinal marrow, and *through* this with an exodic catastatic nerve and *special muscles*.

152. It was during the continued investigation of this subject that I observed that this nervous arc is not simple, but very multiplex, and that it is not one exodic nerve merely which is associated, through the spinal marrow, with the esodic nerves, but that nerves exodic in *all* directions are so associated.

153. The course of excited action may be traced along each and all of these *nerves*. But in what part of their tissue, and along what particles of the spinal marrow, their influence extends, we are utterly ignorant.

154. As each esodic spinal nerve serves for sensation and for conveying diastaltic action, it has been supposed that it contains distinct *fibres* for each of these two offices. And as the same exodic nerve conveys the impulse from volition and from diastaltic action, it also has been supposed to contain *two* appropriate sets of fibres. The same opinion has been extended to the columns of the spinal marrow.

155. Experiment alone can determine such questions definitively; pathology does not afford such distinct isolation of tissues, as to establish their special and exclusive functions; and, in the present instance, I fear that even experiment is inadequate to the task.

156. I beg to recall the experiment of Dr. van Deen, given § 73, to the mind of my reader. It is sufficient to prove the spinal marrow to be

still an unknown region, viewed anatomically, in spite of all that is now said about commissures, and ganglia, and segments, &c. &c. It is indeed the elysium of the critic by profession, and of the guesser in physiology.

157. Facts, experimental and physiological facts, are the only really valuable knowledge we possess on this intricate subject. Pathological anatomy can rarely, as I have already said, be so limited to distinct tissues as to lead to distinct results in regard to their physiology.

158. It is during the *progress* of diseases of the nervous system that our knowledge of its physiology is useful, by enabling us to *interpret* the symptoms, and to determine the *Diagnosis*.

159. The conclusion at which I have arrived may now be stated in a few words :

1. Within the spinal marrow there is a *special Nervous Centre* ;
2. To this centre are essentially attached certain *special Esodic and Exodic Nerves* ;
3. These together constitute a system of *Diastaltic Nervous Arcs* ;
4. The whole of these, taken together, constitute the *Spinal or Diastaltic Nervous System*, viewed Anatomically ; its Physiology will be *sketched* in the ensuing Section.

160. I have now a new fact to detail, which, though not, in our present sense of that word, belonging to the diastaltic system, is still, in its relation to the spinal centre, properly introduced in this place.

161. Many authors, as well as myself, have treated of the relation of the spinal marrow to the circulation. It has been supposed difficult to remove or destroy the whole spinal marrow at once, without simultaneously destroying the circulation by *shock*. I now believe this to be an error ; and that the real cause of the destruction of the circulation has been, not shock, but *loss of blood*. If this latter event be avoided, the circu-

lation remains little impaired, though it gradually and sometimes speedily subsides as the effect of withdrawing the spinal energy.

162. *Exp.*—We took a vigorous frog, and having carefully introduced a probe into the spinal canal, of a size to fill the whole canal or nearly so, we destroyed the entire spinal marrow and brain, leaving the probe so as to fill up the canal. In this manner all hæmorrhagy is prevented. The circulation is observed in all its vigour, only perhaps slightly diminished. In a little time, however, the rapidity of the flow of the blood begins to lessen, and especially in the *arteries*, which gradually enlarge and assume the *appearance* of *veins*. Is this the effect of the loss of tonicity or of nervous power, and a fact affording evidence in favour of the muscularity of arteries and of the *influence* of the spinal marrow on the *arterial* circulation? And is this peristaltic and sphincteric modification of the arterial circulation the efficient cause of secretion and of its subjection to the influence of emotion or stimulus, as in the lachrymal and salivary glands, the skin, &c.?

163. I have only a remark or two to add in reference to the arrangement of the ganglionic system, given p. 24 :

164. By intra-spinal ganglionic system is meant the ganglia on the posterior roots of the trifacial and the spinal nerves. They appear to constitute the ganglionic system of the external organs—the face—the limbs. The extra-ganglionic system is that situated along each side of the spine. The arterio-ganglionic system is that distributed along and to the arteries. The intra-visceral ganglionic system is that distributed to the tissues composing the viscera, and first discovered and fully displayed, as I have stated, by Dr. Robert Lee.

SECTION IV.

PHYSIOLOGY OF THE DIASTALTIC SYSTEM.

165. It is difficult to draw a line of distinction between the Anatomy and the Physiology of the Diastaltic System. The trifacial and the facial nerves, dissected, and viewed singly, are objects of mere anatomy ; viewed as linked together *through* the medulla oblongata, they become objects of physiology, and, as such, of the most intense physiological interest. It is in this manner that I propose to view the subject in the present Section.

§ I.—*The Diastaltic Nervous Arc.*

Figure 8.

166. The Anatomy of the diastaltic system consists in an esodic nerve, the spinal centre, and an exodic nerve, *essentially linked together*, and constituting a *diastaltic nervous Arc*.

167. The Physiology of this system consists in such an arc, or such arcs, in diastaltic action.

168. An appropriate stimulus, applied to any part of this diastaltic nervous arc, induces muscular contraction. In the *Physiological* relations of this *Arc*, the stimulus is always applied at its incipient esodic portions, or *origins*, in the cutaneous or mucous surfaces. In its pathological relations, the source of irritation may be situated in any part of this arc, origin, centre, or termination.

169. How near physiologists were to the discovery of such an *Arc*, yet how far from it, may be seen in the accounts which I have given (in my New Memoir, p. 40—43) of the action of the *Iris*; (in Memoir II, p. 74—76) of the action of the *Eye-lid*; and (in my New Memoir, p. 69—79) of the *acts of Respiration*. More remarkable facts, in every point of view, could not be adduced; and I think they will always preserve a deep historical interest. In all these instances, several parts of the diastaltic *Arc* were discovered; but not one of these *Arcs* was *complete*!

170. I here adduce three examples of diastaltic *Arc*, for the sake of clearness:

I. *The Diastaltic Arc of the Iris.*

I. <i>The Excitor.</i>	II. <i>The Centre.</i>	III. <i>The Motor.</i>
1. <i>The Excitor portion of the Optic Nerve.</i>	<i>The Tubercula Quadrigenima.</i>	<i>The Motor Oculi.</i>
2. <i>The Trifacial.</i>		

II. *The Diastaltic Arc of the Eye-lid.*

I. <i>The Excitor.</i>	II. <i>The Centre.</i>	III. <i>The Motor.</i>
<i>The Palpebral branch of the Trifacial.</i>	<i>The Medulla Oblongata.</i>	<i>The Orbicular branch of the Facial.</i>

III. *The Diastaltic Arc of Respiration.*

I. <i>The Excitors.</i>	II.	III. <i>The Motors.</i>
1. <i>The Trifacial,</i>	<i>The Medulla Oblongata.</i>	1. <i>The Intercostal.</i>
2. <i>The Pneumogastric,</i>		2. <i>The Diaphragmatic.</i>
3. <i>The Spinal, Nerves.</i>		3. <i>The Lower Spinal, &c.</i>

171. In regard to the *first* of these *Arcs*, M. Flourens had shown the influence of the tubercula and of the optic nerve; and Mr. Mayo, of the optic nerve and of the third pair, assuming that these act through the 'brain,' in which Prof. J. Müller agrees with him. In regard to the *second*, M. Magendie demonstrates the influence of the trifacial and facial nerves, but confesses his inability to explain the effect of the section of the former. Mr. Mayo speaks of the 'consent' between the fifth and seventh as arising together. In regard to the *third*, it is well known that Legallois detected the importance of the medulla oblongata, and of the origin of the pneumogastrics more especially; and that Sir Charles Bell gave arrangement to the *exodic* respiratory nerves only, overlooking the *esodic* or *excitors*. The perfect *diastaltic nervous Arc* remained totally undetected in *any* case.

172. Of all the diastaltic nervous *Arcs*, that by which the larynx is closed is the most simple, whilst that by which deglutition is accomplished is the most complex:

The Diastaltic Arc of the Larynx.

I. <i>The Excitor.</i>	II. <i>The Centre.</i>	III. <i>The Motor.</i>
<i>The Superior Laryngeal.</i>	<i>The Medulla oblongata.</i>	<i>The Inferior Laryngeal or Recurrent.</i>

173. The upper part of the pneumogastric nerve is thus diastaltic, and both *esodic* and *exodic*, in reference to the spinal centre. In all this it resembles the lumbar nerve in the experiment detailed in § 143. Whatever doubt there may be as to distinct fibres, there is none in regard to the physiology.

*The Diastaltic Arc of Deglutition.*I. *The Excitors and Motors which close the Larynx.*

II.

I. <i>The Excitors—</i>	II. <i>The Centre—</i>	III. <i>The Motors—</i>
	<i>of Deglutition.</i>	

1. *The Glosso-Pharyngeal?*2. 1. *The Pharyngeal—*2. *The Œsophageal—*3. *The Cardiac—branches
of the Pneumogastric.*
*The Medulla
oblongata.*
1. 1. *The Pharyngeal—*2. *The Œsophageal—*3. *The Cardiac—branches
of the Pneumogastric.*III. *The immediate Excitors of Peristalsis in the Œsophagus.*IV. *The Excitors and Motors which open the Cardia.*

174. This complexity will appear the greater, when we reflect that, in deglutition, the act of closure of the larynx is added to that of the contraction of the pharynx and the œsophagus, and to that of relaxation and opening of the cardia.

175. A similar state of complication of action occurs in the uterine system and its auxiliaries in parturition, and, in a slighter degree, in the evacuation of the rectum, the expulsors being excited and the sphincters relaxed, simultaneously.

176. But in *Respiration* there is, besides the excited act of inspiration, a sustained and continued influence by which the thorax and diaphragm and the abdominal muscles are kept in a state of equilibrium, as it were, in every stage of the double act of respiration—inspiration and expiration; so that, in the *physiological* condition of this function, nothing is abrupt, nothing laborious, nothing audible even, but all is accurately rhythmic and

equable. How different, in cases of pathology, is the varied, irregular,—*diagnostic* condition of this important function!

177. *All* this is effected through those *diastaltic Arcs and Acts* which I have attempted to describe, and which now take their place in the science of *Anatomy* and *Physiology* for the first time.

§ II.—*Guards of the Orifices and Exits.*

178. Besides the acts of *ingestion* and of *egestion*, of which I have briefly treated in the last section, there are other acts or actions by which certain objects are *excluded* from, or *retained* in, the system.

179. The contraction of the iris and the closure of the eye-lids exclude too intense light; that of the larynx excludes certain irritant and noxious gases. The sphincters retain the contents of certain organs, the cardia those of the stomach, the sphincter ani and the sphincter vesicæ those of the rectum and bladder.

180. In this manner certain esodic nerves become the *guards*, as it were, of certain organs. These I have thrown into the form of a *Table*; thus:

- | | |
|-------------------------------------|--------------------------------------|
| I. <i>The Trifacial guards</i> — | 2. <i>The Pharynx, the Cardia.</i> |
| 1. <i>The Eye.</i> | 3. <i>The Ureter, the Gall-duct.</i> |
| 2. <i>The Nostril, the Ear, in</i> | III. <i>The Spinal Nerves</i> — |
| <i>the Cetacea.</i> | 1. <i>The Rectum.</i> |
| 3. <i>The Fauces.</i> | 2. <i>The Bladder.</i> |
| II. <i>The Pneumogastric</i> — | 3. <i>The Vesiculæ Seminales.</i> |
| 1. <i>The Larynx, the Bronchia.</i> | 4. <i>The Uterus.</i> |

§ III.—*The Acts of Ingestion and of Egestion.*

181. All the Acts of Ingestion and of Egestion in the animal œconomy are diastaltic Acts. Each and all depend on diastaltic nervous Arcs, inclusive of an esodic nerve, the spinal centre, and an exodic nerve, essentially linked together.

182. These *Acts* are of great number, and their importance may be estimated by their ultimate objects, which are—

1. *The Support of the Individual, and*
2. *The Perpetuation of the Race.*

They are presented in the following

Table of the Diastaltic Physiological Acts.

1. *Of the Iris ;—of the Eye-lids.*
2. *Of the Orifices*

}	1. <i>The Larynx.</i>
}	2. <i>The Pharynx.</i>
3. *Of the Ingestion—*
 1. *Of the Food,*
 1. *In Suction ;*
 2. *In Deglutition.*
 2. *Of the Air, in Respiration.*
 3. *Of the Semen, in Conception.*
4. *Of the Expulsors, or of Egestion—*
 1. *Of the Fæces ;*
 2. *Of the Urine ;*
 3. *Of the Perspiration ;*
 4. *Of the Semen ;*
 5. *Of the Fœtus, in Parturition.*
5. *Of the Sphincters—*
 1. *The Cardia.*
 2. *The Sphincter Ani.*
 3. *The Sphincter Vesicæ.*

183. Whilst the cerebral system relates to objects *without*— $\tau\alpha \epsilon\xi\omega$ —viewed psychologically, and the ganglionic to objects *within*— $\tau\alpha \epsilon\nu\delta\omicron\nu$ —viewed atomically, the spinal and diastaltic system effects that vortex, or “tourbillon,” as it is designated by Cuvier, by which external objects are drawn in mass *from without inwards*— $\epsilon\xi\omega\theta\epsilon\nu$,—and, having served the purposes of the animal œconomy, are again driven *from within outwards*— $\epsilon\sigma\omega\theta\epsilon\nu$. I think there is an interest attached to these views and these words.

§ IV.—*The Dia- and Peri- staltic Actions.*

184. In § II, I have treated of the diastaltic system as guarding the borders—the orifices and exits—the sphincters—of the diastaltic system. On the *interior* of these borders this system is, in general terms, *tubular*; and, in these parts of it, the action is not purely diastaltic. Thus, according to Dr. J. Reid—

185. “If the pneumogastric nerves be divided above the origin of the superior laryngeals in the rabbit, the principal part of the parsley eaten by the animal remains in the œsophagus; a few leaves are all that reached the stomach.” On the other hand, I myself observed that, if the œsophagus, thus replete with food, be placed on the table for observation, that food is slowly and gradually expelled by peristaltic action.

186. The act of deglutition in the pharynx and œsophagus is, therefore, *dia-* and *peri-* staltic. I refer my reader for further details on this point to my ‘New Memoir,’ p. 53—.

187. The same remark doubtless applies to all the *tubal* acts of ingestion and egestion, and especially to those of the rectum and the uterus. The *degree* in which these acts are diastaltic and peristaltic respectively is, as yet, unknown.

188. Perhaps, as I have already said, the Acts of Respiration are the only purely diastaltic.

189. Another question, of singular interest, is suggested by the experiment detailed in § 161. How far are the peristaltic movements of the heart (and arteries?), the stomach and intestines, &c. dependent on, or affected through, the spinal centre, and therefore, in reality, *dia-staltic*?

190. I place before me the whole subject of *Peristaltic* actions for future investigation—their *degree* of dependence on the spinal centre, their *form*—(for, whilst the diastaltic acts are prompt and intermittent, these are more gradual and continuous); the case of antiperistaltic action; &c.

191. I believe we shall, in this inquiry, discover the real value of the *ganglionic*, as a *sympathetic*, system. Hitherto it has been supposed to play too great a part in the *Sympathies*; its influence in these is now in danger of being rejected entirely (see ‘New Memoir,’ § 18); the truth lies between the two extremes; the spinal and the ganglionic have each their appropriate sphere of sympathetic action.

§ V.—*Respiration alone purely Diastaltic.*

192. Next in vital importance to the action of the heart itself, are the acts of Respiration. Strange that the real origin and nature of these Acts should have remained utterly unknown! See § 171.

193. Viewed as voluntary, and induced by a sense of oppression—the “*besoin de respirer*,” by one author, and as *originating* in the medulla oblongata by another, the real cause of the *Act of Inspiration* remained undetected.

194. Each act of respiration is, in reality, an excited act; and each excited act requires a renewal and repetition of the exciting cause. What

is this cause, and what the manner of its repetition? Even recently it has been supposed that this exciting cause is the venous blood circulating in the lung (Dr. Carpenter), or in the system (Prof. Volkmann). But this idea is defective in the essential requisite of alternation and repetition. The circulation of venous blood is continuous, and any deviation is gradual. The real exciting cause of inspiration is the evolution of carbonic acid in the pneumonic circulation. As the venous blood flows along the pneumonic methæmata, this gas is exhaled; it diffuses itself in the air-cells, mingling with the atmospheric air in them; and when its accumulation is sufficient, it excites the pneumogastric, the internal esodic respiratory nerve, and an act of inspiration is accomplished. This effect is produced rapidly, precisely in proportion to the rapidity of the circulation, and of the exhalation of carbonic acid. The proportionate rapidity of these two functions, in health, is thus explained: all disproportion between them is pathological, and the measure of this disproportion is the measure of the pathological condition, a condition usually dependent on that of the *Centre* of the diastaltic nervous system.

195. Each act of inspiration is immediately followed by an act of expiration, these two acts being linked and sustained together as I have already described. By the act of expiration the evolved carbonic acid is carried away, until, by the fresh evolution of a fresh portion of this gas, fresh acts of inspiration and expiration are excited. In this manner the alternation of the respiratory acts is explained, by that of the cause, and the removal of the cause.

196. Such is the rationale of the rhythmic acts of respiration. But the pneumogastric is not the *only* excitor of respiration. It is not the *first* excitor of this function. The first excitors of respiration are in reality the trifacial and the cutaneous spinal nerves, by the contact of the cool atmosphere. These being excited afterwards by the contact of cold

water, as in bathing, again excite supplementary acts of inspiration. But such excited acts of inspiration are accidental, irregular, unrhythmic, and unlinked with the succeeding expiration, which is also unsustained. The acts of inspiration are, in this case, sudden, sob-like, perhaps unrepeated, or repeated irregularly, and unlinked with an equable expiration.

197. Such an act of respiration is almost as different from ordinary respiration as the gasping which closes the vital career, and which is of centric origin, the medulla being, in this case, in reality the *primum mobile*.

198. Of the precise relative value of the trifacial and spinal nerves, and of the pneumogastric, as excitors of respiration, we are at present totally ignorant. The former may be auxiliary, in a manner and degree still unknown.

199. In birds, the spinal nerves, distributed over the systemic air-cells, act as the pneumogastric.

200. One point is of the greatest interest: we observe, in experiments with suspended respiration, that an act of inspiration may be excited by stimulating *any* part of the general surface. Inspiration may be of panthodic *origin*. In like manner, dashing cold water on the face excites *all* the organs of the diastaltic system. In this case the *course* of action is panthodic.

201. In any case, the action of the larynx, the intercostals, the diaphragm, is simply and purely diastaltic.

§ VI.—*Relaxation of the Sphincters.*

202. A sailor lies with his abdomen across the yard-arm. The pressure of the whole weight of his body is therefore on the sphincters,—

the cardia, the sphincter ani, the cervix vesicæ; yet these sphincters do not fail in their office. But, in deglutition and in vomiting, and in the act of relief of the intestines, and of the bladder, as in that of the uterus in parturition, there is absolute and positive relaxation of the sphincters, and the organs which they usually close are evacuated without resistance.

203. I mention this fact, chiefly to call the attention of physiologists to its investigation.

§ VII.—*Sensation ; Volition ; Emotion.*

204. Some diastaltic Acts, as that of *deglutition*, are entirely unattended by sensation. Others are accompanied by this psychical act. The association is not necessary.

205. Many diastaltic Acts are modified, or rather modulated, by volition. Such is the case with *Respiration*, which becomes audible, and even irregular, if, as in intense attention, or in sleep, volition be withdrawn.

206. Every diastaltic Act admits of modification by emotion, as, indeed, do all peristaltic movements and secretory processes. This effect is seen in *Respiration*, in the action of the heart, in the secretion of the saliva, &c. The influence of emotion is, indeed, both diffusive and extreme.

207. Emotion and the diastaltic principle are the great agents in the *Instincts*, which are chiefly directed to the search after food, the union of the sexes, and the care of offspring, and as inscrutable as the most elementary powers of the intellect.

SECTION V.

OBSTETRICS BASED ON THE DIASTALTIC SYSTEM.

208. CONCEPTION and parturition are principally *diastaltic spinal Acts*. The science and art of *Obstetrics* are, therefore, chiefly founded on the doctrine of *The Diastaltic Nervous System*.

209. I have mentioned this fact in various parts of my writings*. In 1841, I wrote—‘The whole question of abortion and parturition, and, in a word, of *Obstetrics* as a science, is one of the true spinal system; and he will do humanity great service who, with suitable opportunities, will trace it fully†.’ And—

210. ‘It is plain that much of the science of *Midwifery* belongs to the subject of the true spinal system; and I doubt not that many improvements in this branch of medicine will result from our knowledge of this system. Inertia of the uterus may probably be remedied by some of the agents which operate on the incident nerves, especially the impulse of cold water. I have witnessed the beneficial effect of dashing cold water over the hypogastric region in continued uterine hæmorrhagy.

* I refer my reader to my 8vo volume on the ‘Diseases and Derangements of the Nervous System,’ pp. 74—76, 112, 114, 341, &c.; to my ‘New Memoir,’ p. 56; to my ‘Observations and Suggestions,’ Series I, p. 150; &c. &c.

† See ‘Diseases and Derangements,’ p. 341.

I knew an accoucheur who always applied a sponge of cold water to the face freely before proceeding to pass the female catheter, and sometimes with success. A similar impression of cold is known to move the bowels*.' And again—

211. 'Of all the facts in physiology or pathology, the nature of conception and the case of sterility are perhaps the most obscure. Excito-motor in its nature, conception involves the ingestion of the semen and the grasping of the ovum. Exhausted excito-motor power, structural defect, or pathological change in the condition of the uterus or its appendages, may be the cause of sterility.

212. 'Abortion, on the other hand, may, like the case of morbid susceptibility and seminal emission, arise from undue excitability, and must be treated on the same principles.

213. 'How important this subject is in itself, how much it is in need of new investigation, how necessary it is to rescue it from the hands of the dishonest empiric, I need not say. The first step in the investigation is, to have traced the phenomena to their appropriate organ in the nervous system, and to their principle and mode of action. That that organ is the true spinal marrow, that that principle is the *vis nervosa* or excito-motor power, and that mode, reflex, are too obvious to need further proof. The phenomena may take place irrespective of the cerebrum; and are only dependent for the secretions required for them on the ganglionic system. They are in every respect similar to others indubitably excito-motor.

214. 'The uterine system is to the species, what the gastric is to the individual†.' In 1843, I added—

* Diseases and Derangements of the Nervous System, p. 76.

† Ibid p. 112.

215. 'The acts of conception and of parturition doubtless belong to the same order.

216. 'The expulsion of the fœtus in the human subject is sometimes induced by local excitement. The application of a few grains of salt to the sphincter has induced the expulsion of an immature egg in the hen. I have also seen the eggs expelled from the separated abdomen of the libellula by the rough contact of external objects.

217. 'In connection with these latter subjects, I may observe that the next improvement in the obstetric art will, I believe, arise from the application of our knowledge of the excito-motor principle to that department of medicine. Remedies in the cases of sterility and of lingering labour, in atonic hæmorrhagy and other forms of inertia of the uterus, will probably be found in some of the excitants of the excito-motor power*, &c. &c.

218. "Some years ago, Dr. Tyler Smith, at my instance and request, commenced the study of the applications of the reflex function to obstetrics. Since that time, he has constantly laboured, with great ability and success, at this subject. Upon the commencement of his investigations, I promised Dr. Smith to assist him in the matter by any suggestions or advice which might occur to me; and I have constantly done so."

219. The result has been one of those works which stamp the age in which we live, and do honor to the science and profession of Medicine, and especially of Obstetrics, which are now guided by a *physiological* principle for the first time.

220. It remains to determine the relative value of diastaltic action, of voluntary effort, and of peristaltic action, in parturition, and the influence of emotion. It remains to determine the reciprocal diastaltic, peristaltic, and secretory *sympathies*, between the ovarium, the uterus, and the mammæ.

* 'New Memoir,' p. 56.

221. The sympathy between the ovarium and the mammæ is one of the ganglionic system; that between the mammæ and the uterus is frequently diastaltic—as in the case of contraction induced in the uterus on the application of the infant to the nipple, and as in the well-known case treated by the late celebrated Prof. Gregory:

222. A lady had frequently miscarried at an early period of uterogestation, with profuse hæmorrhagy, and had therefore never borne a viable infant. On one of these occasions, Dr. Gregory recommended the application to the mammæ of a robust infant: lactation was induced, and continued, and a child, and afterwards others, were carried to the full period.

223. Dr. Tyler Smith has extended the ovarial theory of the catamenia to parturition as a multiple catamenial period, with much ingenuity. The dissimilarity in the two events appears to me to be this: at the catamenial period there is the separation of an ovum, which descends through the Fallopian tubes and the uterus; in parturition no such event occurs, and the ovarium is free from the catamenial tumefaction and congestion. Can the superinduced condition of the mammæ have any relation to the parturient action of the uterus? We know the effect of excitement of the nipple and mammæ by the infant, after parturition, in inducing diastaltic action of this organ, to which I have just adverted.

224. But I leave this subject in the hands of Dr. Tyler Smith, to whom I formerly committed it, and to such others as, perceiving its importance, and having the ability and the opportunity, may enter with him on this career of investigation. It must only be understood that—*Obstetrics are a Part and Branch of the Diastaltic Nervous System*,—and that—I pointed this out repeatedly and emphatically many years ago.



SECTION VI.

THE PATHOLOGY OF THE DIASTALTIC SYSTEM.

§ I.—*General Observations.*

225. I AM about to enter upon a most important and extensive branch of my subject—that which binds the interests of physician and of patient strictly together.

226. I regard a knowledge of *The Diastaltic System* as the great means of advancing the Pathology of the diseases of the nervous system.

227. “To know the disease”—how vast the task! how little comprehended by the crowd of the feeble of intellect who are given up to the quackeries of the day!

228. Here again anatomy and physiology, aided by experiment and observation, are our only sure guides. And yet experiment itself is, as the “father of Medicine” justly asserted, apt to be fallacious (*σφαλερη*). Of this I could adduce many recent examples. But I prefer to occupy myself with truth itself, rather than waste my time in criticism.

229. Experiments, if well devised and executed, may, especially, present to our contemplation the *Types* of diseases, with this advantage, that they *may be limited* to the organs whose maladies we may be inves-

tigating ; not indeed if performed by piercing the cranium and its many tissues with “bradawls,” and subjecting these tissues to the diffusive violence of the “magneto-electric rotation machine ;” but by the method of isolation so admirably pointed out by M. Flourens, in his classical work*.

230. I have already observed that the cerebrum and cerebellum are astaltic, or inexcitor. No disease *limited* to these can, therefore, be attended with *spasm*.

231. The tubercula quadrigemina are excitor with a *crossed* effect.

232. The medulla oblongata and the medulla spinalis are staltic or excitor, *without* crossed effect. *Irritation* of these organs induces spasm, on the side affected.

233. The dura mater and other internal membranes are diastaltic ; that is, they excite muscular actions *through* the medium of the spinal centre. Hence, dental, gastric, intestinal, or uterine irritation may excite diastaltic convulsive disease.

§ II.—*Causes and Forms of Morbid Staltic Action.*

234. The causes which act on the spinal system are—

I. Those which act on its *Centre*—

1. *Emotion* ;
2. *The Blood* ;
3. *Arachnitis* ; *Encephalitis* ;
4. *Exostosis* ; *Tumors* ; &c.

* Du Système Nerveux ; Preface ; especially p. viii—x ; ed. 2. “Haller, Zinn, Lorry, Saucerotte”.—“se bornaut à ouvrir le crâne et à enfoncer un trois-quarts”—“ne savaient jamais réellement quelles parties ils blessaient, ni conséquemment à quelles parties ils failloit rapporter les phénomènes qu’ils observaient.” To *return* to such a mode of experiment, is to retrograde in science.

II. Those which act on the *Esodic Nerves*—

1. *Dental* ;
2. *Gastric* ;
3. *Enteric* ;
4. *Uterine* ;
5. *Traumatic* ;
6. *From Internal Tissues.*

III. Those which act on *Exodic Nerves*—

1. *Tubercles* ;
2. *Tumors* ;
3. *Inflammation* ;
4. *Wounds* ;
5. *Lesions of adjacent Tissues.*

235. A volume might be written on the effects of Emotion on the Diastaltic and the Peristaltic and Secretory Systems. Another volume might be written on the effects of morbid states of the blood, both in regard to quantity—excess or defect, and to quality—from defective ingesta, or assimilation, or secretion—(purification), or from poison.

236. For adequate treatment of *each* of the irritations, a similar space would be required.

237. The process of dentition is one of energetic arterial action. It is deeply seated within the alveolæ, and is attended with augmented temperature and tumefaction of all the adjacent tissues, the nervous with the rest. The scarification of the gums should be viewed as the remedy for this state of things, by inducing the flow of blood, not as merely dividing the tense gum over the teeth.

238. Any indigestible substance, eaten, is not only a source of gastric irritation itself, but the excitor of undue secretion of the gastric juice and acid—the hydrochloric—a second source of gastric irritation. Dilu-

ents and antacids—or more effectual still, an emetic—a dose of ipecacuanha—are the remedies.

239. For enteric irritation, an efficient antacid aperient, timeously followed by an ample enema of gruel, affords the most prompt relief; the cause usually being scybala or other morbid contents of the intestines.

240. Uterine irritation is that which is observed at each catamenial period, at the period of conception, and at various periods of utero-gestation. Acidity, sickness and vomiting, and various *seizures*, are the usual effects of this kind of irritation. One patient had an attack of epilepsy at each catamenial period for many years, from the very first, uninfluenced by marriage. She had no family. The attacks were suspended by a light mercurial treatment, with repeated blisters applied over the ovarial regions.

241. Of the traumatic cause of diastaltic morbid action in tetanus, I need only say that, in *degree*, not in *principle*, it differs from others.

§ III.—*Morbid Diastaltic Action and Excitability.*

242. The most ordinary form of spinal or diastaltic malady is that of morbid excitement of an esodic nerve, as in dental, gastric, enteric, and uterine irritation.

243. Sometimes the source of such irritation is seated in an internal serous or fibrous membrane. I have observed diastaltic action from irritation of the dura mater at the base of the cranium in an experiment; and irritation of the pericardium, in disease, has appeared to produce the same effect in the human subject.

244. Besides these forms of mere irritation, the spinal marrow is apt, in such cases, to take on a state of undue excitability: this state is seen in

its extreme degree in tetanus ; but it exists, in a minor degree, in the convulsive affections arising from dentition, and in epileptic and epileptoid diseases. Hence the tendency to relapse in these maladies.

245. In some affections, the entire disease consists in such augmented *excitability* ; as in the state induced by strychnine, and in hydrophobia, in which *no spasm exists unless excited*, the *cause* being seated in the *blood*.

246. In other cases there is undue *excitability*, together with more or less of permanent and actual *excitement*. The extreme case of this kind is that of tetanus ; other cases are those of convulsion from dental irritation, and in the puerperal state, and epileptoid affections in general.

247. Tetanus differs from hydrophobia in this : whilst hydrophobia is a poisoned state of the blood, inducing extreme excitability merely, tetanus is a disease of nerve-origin, with equally augmented excitability, and constant actual nerve-excitement. In the former, the spasms are *inter-mittent* ; in the latter, they are *re-mittent* only : in the former, the spasms are reproduced, in the latter, they are, in the highest degree, exasperated, by each fresh excitation.

248. Each such excitation and its consequence are followed by exhaustion of the *powers* of the system,—of the spinal marrow and of the heart ; and in proportion to these is the rapidity of the malady in the individual case. In the proportion in which such excitations are avoided, are the hopes of recovery—a fact of extreme importance in the treatment as well as in the pathology of this dire disease.

249. It is obvious, I think, that the division of the wounded nerve must have the effect of rendering the remittent spasm intermittent. Whether any further good effect, such as diminution of the augmented excitability, would also ensue, is a question still undetermined and full of interest.

250. Similar questions occur with regard to dental and other sources of irritation in infants. By removing these, excitation must cease; does the excitability undergo diminution?

251. The same remarks apply to the cases of gastric, enteric, and uterine irritation, in adults. If the sources of these be removed entirely or in part, the augmented state of the excitability may still remain for a time, and require its appropriate remedies.

§ IV.—*Pathological Diastaltic Acts.*

252. I have enumerated, in § II, the principal *causes* or *origins* of diastaltic diseases; and, in § III, I have adverted to the modified excitability which obtains in them. It remains for me to trace, in the present section, the exodic part of the pathological diastaltic Arcs. To do this adequately, would be to detail every symptom of spasmodic form in these maladies. I can only give the most prominent.

253. Dental irritation, acting through the spinal centre, in which a morbid degree of excitability is induced, is seen in its effects on the muscles of the eyes, the fingers, the toes, inducing strabismus, and spasmodic flexion. The features, the neck, and the limbs, are distorted in succession. The larynx is closed, and there are morbid efforts of the expiratory muscles. The consequence is, compressed veins of the neck, and congested encephalon.

254. *Similar* phenomena are observed in the adult, from gastric, enteric, uterine irritation, the affection receiving, wrongfully, the formidable designation of epilepsy. That of *epileptoid* would be more just and more appropriate.

255. *Similar* phenomena occur, constituting the various forms of puerperal convulsion.

256. Lastly, *similar* phenomena take place from organic lesion within the cranium—a case to be carefully distinguished from the former.

257. In all these cases there is something *specific*, both in regard to *cause* and its *effects*. It is usually the *same* cause which operates, usually the *same* phenomena which are produced. Yet this statement is not to be received absolutely: the undue excitability superinduced leads at length to such susceptibility, that *any* cause, acting on the diastaltic system, may renew the seizure; and *effects* may be produced within the cranium which may entirely change the external *form* and the degree of *severity* of the malady.

258. After the causes to which I have adverted, mental *Emotion* is by far the chief.

259. After this, I would enumerate morbid conditions of the *Blood*, arising from defective secretions or purification.

260. All act, through the spinal marrow, directly or in a diastaltic manner, upon the exodic or muscular portion of the nervous arc, and, through this, upon *The Neck*, and the larynx, chiefly, and eventually upon the encephalon,—the cerebrum and the medulla oblongata.

261. All this may be distinctly seen and traced by the observant physician, and, with him, really admits of no dispute.

262. What I have stated is sufficient for illustration, or I might advert to the phenomena of hydrophobia, of tetanus, &c. in all which something *specific* in the course of events will still be found. As the muscles of the tongue, in epilepsy, so those of the lower maxilla, in tetanus, are in some measure distinctively affected. In hydrophobia, as in almost all the maladies of this *Class*, the larynx is most formidably involved. In all, our knowledge of the diastaltic nervous system is our guide, in *Practice*, to the *Pathology* as to the *Treatment*!

§ V.—*Morbid Affections of the Acts of Respiration.*

263. Normal respiration is rhythmic, equable, noiseless, and performed with the utmost regularity and equilibrium; and there is a sustained proportion between the number of acts of respiration and of systole of the heart.

264. There is no more important source of *diagnosis* than the respiration, with its modifications in disease.

265. Purely diastaltic, as I have stated, it is yet modulated by volition, and it becomes audible during intense attention and during sleep; nay, it is even suspended for a moment, and then renewed by a sigh.

266. The same result is observed, in a still more marked manner and degree, in *all* cases of disease by which the medulla oblongata is impeded in its functions, however slightly.

267. I have observed these symptoms in various affections of the head in children—in hydrocephalus, in the hydrocephaloid disease, after a convulsive fit, &c. It always indicates *danger*, in proportion to its degree and duration.

268. The respiration ought not to be *audible*: stertor always denotes an affection of the medulla oblongata; audible breathlessness or panting, however apparently slight, if without immediate exciting cause, frequently denotes a *dangerous* degree of exhaustion.

269. Stertor denotes danger in apoplexy, in proportion to its *degree* and its *continuance*. If it do not speedily subside under active remedies, the case is usually fatal. This remark is also applicable to dysphagia.

270. Disproportion between the number of respirations and of pulsations is the *sign*, and also, according to its degree, the *measure*, of danger. The acts of respiration are apt to become less frequent, whilst the action

of the heart is accelerated. But sometimes both the respiration and the beats of the heart become variously slow and irregular.

271. In normal respiration, the thorax and the diaphragm are nearly equally moved. In many cases of affection of the encephalon, the respiration becomes more diaphragmatic than thoracic.

272. In some cases of *sinking*, the respiration is attended by a small mucous rattle, audible without the stethoscope. This symptom is usually fatal. It denotes lost energy of the ganglionic system, that energy by which the secretion and absorption of the bronchial mucus are balanced.

273. In normal respiration, the thyroid cartilage scarcely moves; but in dyspnœa, and especially in the state of sinking, this cartilage is drawn down suddenly at each inspiration.

273. I refer to my 'New Memoir,' for the great distinction between the normal diastaltic respiratory movements, and the gasping and other morbid actions of the respiratory muscles, of centric origin, in asphyxia; pp. 69-80—.

§ VI.—*Interference of Emotion and Diastaltic Action.*

274. There are *three* maladies similar in *form*, however dissimilar in *cause*, to which I must briefly advert in this place. They are—stammering, chorea, and paralysis agitans. There is undue excitability of the spinal centre; and emotion and diastaltic action *interfere* with the acts of volition.

275. When the stammerer wishes to articulate, the voluntary action of the organs of speech is carried to excess, by spinal or staltic action, or rendered abortive by emotion.

276. In chorea, the acts of volition are rendered more or less nuga-

tory by the aberrations of movements induced both by emotion and staltic action.

277. In both these maladies, absolute freedom from volition and emotion is, at the first, freedom from agitation, as during quiet sleep.

278. Later in the disease, a certain degree of agitation is observed during sleep, perhaps from dreaming.

279. In the commencement, these affections are probably functional merely; afterwards, centric organic lesion is probably superadded.

280. Though spinal in their origin, they are apt, in a greater or less degree, to assume the *hemiplegic* form, though this is *usually* characteristic of cerebral disease. The same remark applies to the epileptoid affections.

§ VII.—*Muscular Paralysis of the Arms.*

281. Before I conclude this section, I must notice a condition of the nervous system of which I have seen two examples.

282. The patient loses the muscular power of both arms and hands, the latter being somewhat distorted, sensibility remaining, and nutrition being impaired. If we imagine periostitis or other disease of the posterior part of the bodies of the vertebræ, in the region of the roots of the brachial plexus, we explain the compression or other lesion of the anterior roots of the brachial nerves, and the phenomenon of loss of muscular power, with the persistence of sensibility. A fact in corroboration of this view, is, that the spinous processes of the cervical vertebræ in this region are a little protuberant, whilst the head falls somewhat upon the thorax.

§ VIII.—*Withered Limbs.*

283. It is not unusual to see a withered arm and hand, and leg, on one, or even on both, sides of the body, whilst the trunk, with the internal organs, is perfectly developed, deglutition and the action of the sphincters being also perfect. What is the probable rationale of such a case? Is the intra-spinal ganglionic system injured by spinal arachnitis or effusion, whilst the extra-spinal ganglionic system is uninjured?

§ IX.—*Digiti semi-mortui.*

284. I have another observation to make. It not unfrequently happens, in certain persons, that, from the influence of moderate cold, one or more fingers become pale and death-like, as if bloodless, and as if life-less.

285. One finger only, or one part of a finger, may be thus affected alone; or several, or even all, of the fingers may thus become semi-mortuous.

286. I think that, if punctured, there would be little sensation or flow of blood.

287. What is the nature of this singular affection? It appears to me to be ganglionic paralysis of the digital arteries.

SECTION VII.

THE DIASTALTIC SYSTEM IN RELATION TO DIAGNOSIS.

§ I.—*General Observations.*

288. A KNOWLEDGE of the Diastaltic System and its Phenomena, is the great means of the *Diagnosis* of Diseases of the Nervous System. It is to these diseases, in some measure, what the *Stethoscope* is to those of the heart and lungs.

289. It is by the absence or presence of these phenomena from the beginning that we determine the limitation of disease of the cerebrum to that organ, or its extension, in influence or actual lesion, to the spinal marrow.

290. I may mention hydrocephalus in infants, and apoplexy in adults, as examples of this fact. In the commencement of the former, the symptoms are cerebral and obscure; but, as the disease advances, staltic or spasmodic actions *denote* and almost *measure* the fact. In apoplexy, the respiration is frequently stertorous, and there may be dysphagia, or there may be various convulsive affections of the limbs. If these symptoms subside, we may conclude that the disease originates in cerebral congestion, which is receding, and with it the immediate danger; but if they remain permanent, we must fear that the disease is formidable organic lesion, and will prove fatal.

291. I have already observed that diseases of the cerebrum, *limited* to the cerebrum, cannot induce *spasm*, this organ being *in-excitor*. But, in the case of congestion or other lesion, there may be tumefaction of its structure, and counter-pressure on the medulla oblongata, and consequent affection of the larynx and throat, the muscles of respiration, and the muscular system variously, spasmodic or paralytic.

292. A tumor, or exostosis, within the cranium, may irritate or compress the spinal structures. The former condition leads to spasm; the latter, to paralysis. The *base* of the cranium presents an object of study to the physician, of extreme interest.

293. If, in the case of paralysis, there be also *spasm*—if it be *spasmo-paralysis*, two inferences may be drawn: the first, that the spinal system is affected; the second, that it is *irritated*, not *destroyed*,—a diagnosis of extreme importance in the prognosis and treatment.

294. If, in the case of paraplegia, diastaltic actions remain in the affected lower extremities, two inferences may again be drawn: first, that the seat of the disease is so high as to leave a lower portion of the spinal marrow; secondly, that this lower portion of the spinal marrow is intact.

295. If paraplegia comes on very slowly, the great question again is—Is there, or is there not, *spasm*? In the former case, it is irritation; a mild mercurial course has appeared to me to be the remedy: in the latter, it is probably *exhaustion*; and I have seen great benefit from the fiftieth part of a grain of the acetate of *strychnine*, given three or four times a day.

§ II.—*Epileptic and Epileptoid Diseases.*

296. But the great distinction to which we are led by a knowledge of the phenomena of the Diastaltic Nervous System, is in regard to

- I. *The Esodic,*
- II. *The Centric,* and
- III. *The Exodic, Diseases* of that system. See § 234.

297. These diseases are severally represented in *figures* 3 and 2.

298. Let us take epilepsy as an example. Every one knows the almost hopeless case of epilepsy of intra-cranial origin. Such is the force of *language*, that the same ideas are attached to those forms of epilepsy, or rather those *epileptoid* affections, which arise from irritation of organs distant from the nervous centres, acting through *esodic* nerves. This important *Diagnosis* is to be effected by carefully tracing the symptoms to their *source*, and by further tracing the influence of that source and cause of the disease upon its varied forms.

299. The attacks of *centric* epilepsy are generally more sudden and more formidable than those of *epileptoid* diseases arising from *ex-centric* causes.

300. Formidable as the convulsions arising from teething, or occurring in the puerperal state, may be, no one attaches to them the *same* idea which is attached to epilepsy of *centric* origin. The same difference of idea ought to be attached to the *epileptoid* affections arising from gastric, enteric, or uterine irritation.

301. In the latter case, the malady is frequently not only traceable to an *ex-centric* source, but suspended by appropriate remedies. The diagnosis points at once to the proper principles of treatment; and this diagnosis is founded upon the physiological principles which have been laid down.

302. It would occupy too much space to give even aphoristic expression to all these topics, as I have hitherto attempted to do to the other subjects of this little volume. I will only add a specimen of the manner in which the *links* of this *chain* hang together.

303. I will again take epilepsy as an example, and sketch the precise mode of action of the causes of epileptoid diseases :

304. They all act diastaltically through the spinal centre, and induce strabismus, distortion of the features, a bitten tongue, contraction of the hands and fingers, or toes, or both ; spasmodic action of the muscles of *The Neck*, the cleido-mastoid, the trapezius (*trachelismus*), &c. compressing the internal jugular and the vertebral veins (*phlebismus*), and inducing congestion of the features, brain, and medulla oblongata ; this state is augmented by closure of the larynx and expiratory efforts ; insensibility, general convulsion, coma, &c. are the dire results ; and, more remotely, perhaps paralysis, perhaps mania.

305. Few maladies have been so traced, link by link. I will only further illustrate this part of *Diagnosis* by adding the following

Table of the Epileptoid Seizure.

I. <i>The Esodic or Excitors.</i>	II. <i>The Centre.</i>	III. <i>The Exodic or Motors.</i>
1. <i>The Pneumogastric in the Stomach.</i>	<i>The Medulla oblongata.</i>	1. <i>The Recurrent, inducing Laryngismus ;</i>
2. <i>The Spinal in</i> 1. <i>The Intestine.</i>		2. <i>The spinal Accessory, the Descendens noni, &c. inducing Trachelismus ;</i>
2. <i>The Uterus.</i>		3. <i>The Spinal, inducing</i> 1. <i>Forcible Expirations ;</i> 2. <i>General Convulsion ; &c.</i>

306. Such *Tables*, illustrated by *Diagrams*, might be drawn out, illustrative of all the diseases of the nervous system.

§ III.—*The Neck, as the Seat of Morbid Diastaltic Actions.*

306. I have already adverted, § 304, to *The Neck* as a special seat of abnormal diastaltic actions.

307. But the importance of this subject is too great to admit of its being dismissed so summarily ; and I propose to treat of it a little more at length in this place.

308. It frequently happens that, from emotion, and from dental, gastric, intestinal, or uterine irritation, various spasmodic affections occur, assuming an epileptoid character. Of these, strabismus, laryngismus, and various contractions of the fingers, toes, &c. are the most familiar and generally known.

309. The features are also frequently distorted, and the head is variously twisted to either side.

310. The muscles of *The Neck* are frequently contracted in a less violent degree, yet still with dire effects, arising from compression of the subjacent veins. In this case, various ulterior effects on the encephalon occur in their turn.

311. Sometimes these assume the external character of a momentary oblivium, delirium, or giddiness ; sometimes, of various spasmodic, convulsive, or epileptoid affection ; sometimes, of *paroxysmal* paralysis, or mania. As a further effect of this trachelismus, a more fearful convulsive, paralytic, or maniacal seizure may take place.

312. Such seizure may occur in a form and degree to admit of its passing away unknown to, or unrecollected by, the afflicted patient, and unnoticed by any other person. Such a seizure I have designated a '*hidden seizure* ;' and I believe it to be the too frequent *cause* of maladies of the nervous system, not hitherto understood. Mania and paralysis—

and *crime*—may have this origin! I need not observe how momentous, in such a case, is the *Diagnosis*. The prognosis and the treatment, and possibly judicial proceedings, may depend upon it.

313. It is remarkable that the *recurrent*, the *accessory*, and the *descendens noni*, nerves so strange in their course, are special exodic agents in inducing laryngismus and trachelismus, though this latter involves also the agency of other nerves of this sub-class.

314. *Sleep* has a remarkable relation to *paroxysms* and *seizures*; it is in itself probably the result of slight trachelismus, of slight phlebismus therefore, and slight congestion of the encephalon. Can we be surprised that it should predispose to maladies whose essence is an aggravated form of the same condition?

315. The emotion of shame produces blushing, from acting (through the *descendens* of the facial nerve) on the posterior portion of the platysma myoides, thus compressing the external jugular veins. The more violent emotions of anger and fear act on the cleido-mastoid, the trapezius, the omo-hyoid, and induce epileptoid or other seizures, some of which assume the form of mania, or of paralysis.

316. What emotion does, gastric, or intestinal, or uterine irritation may do; and we have, in 'sick-headache,' the *type* of a *Class* of maladies, of which the first link is such irritation, and the last the effect of impeded venous circulation in the encephalon*. Instead of headache, there may be vertigo, momentary oblivium, or deafness, or blindness, or danger of falling, with the sickness, or with acidity, flatus, &c.

* See further, *The Lancet* for 1849, passim, for papers on *The Neck as a Medical Region*, and on *Paroxysmal Diseases*.

§ IV.—*Spasmo-Paralysis.*

317. Paralysis may arise from *lesion* of the cerebrum or of the spinal marrow, by which term I now mean disintegration of structure.

318. *Spasmo-paralysis* implies *irritation* of some part of the diastaltic system, with or without such lesion.

319. Spasmo-paralysis may arise from disease seated within the cranium, affecting the membranes, the esodic nerves in their intra-cranial course, or the medulla oblongata ; or

320. It may arise from any disease within the spinal canal, partly irritating, partly crushing, or otherwise injuring the spinal marrow.

321. It may also be left as an *effect* of a spasmodic or convulsive seizure. I have seen such effect as the result of the irritation of dentition in infants, and as the result of epileptoid convulsion in adult age.

322. There is a form of this affection which I have designated *paroxysmal* paralysis. It is as sudden in its origin, and almost as transient in its duration, at first, as the paroxysmal spasmodic symptoms in convulsive diseases.

§ V.—*Types of Pathology presented by Experiments.*

323. *Exp.*—If we take a frog and divide the spinal marrow near the cranium, the animal is affected by *shock*: the diastaltic force is suspended, there are no diastaltic actions, or only such as are very feeble. In a few minutes the diastaltic power and phenomena are restored, the effect of shock having passed away. What effect is produced on the heart, independent of loss of blood, is not known. See § 161—162.

324. In the same manner, a violent blow on the tibia paralyses the limb for a time.

325. If an arm be torn off by machinery, or a limb be crushed by a railway carriage, or if there be a fall from scaffolding, a state of shock is induced. A *similar* state of shock occurs in the case of laceration or rupture of an internal viscus. The first effect of sudden hemiplegia is *shock*. The effect of ruptured pleura, gall-bladder, stomach, intestine, bladder, uterus, &c. is *shock*.

326. *Exp.*—If, when recovery from shock has taken place in the frog, we introduce a needle into the spinal canal and irritate the spinal marrow, we observe many kinds of convulsive action, or *spasm*, according to the part irritated.

327. Arachnitis, exostosis, and other intra-spinal diseases, produce the same effects.

328. *Exp.*—If we now *destroy* various portions of the spinal marrow, we observe, during the process, various spasmodic and convulsive affections; but the result is *paralysis*.

329. In like manner, the effect of irritation of the spinal marrow in disease, is *spasm*, or convulsive affection; but the effect of lesion to disintegration of the structure, is *paralysis*.

330. *Exp.*—If we irritate or divide the spinal marrow in a frog, the anterior and posterior extremities, or the posterior extremities only, are affected by spasm, or paralysis, according as the point irritated or divided is *above* or *below* the origin of the brachial plexus of nerves.

331. So, in the human subject, the precise *seat* of the disease is indicated by that of the spasm or paralysis, the mode of oblique exit of the spinal nerves from the spinal canal being borne in mind.

332. *Exp.*—In some irritations of the spinal marrow in the frog by the galvanic current, the effect has *ascended*; and, although the part

irritated was seated *below* the origin of the brachial plexus, the anterior extremities were slightly moved, with less of *jerk* than when the irritation was applied *above* that origin.

333. This fact has, I believe, been observed in the *similar* case of disease or injury in the human subject. It may accompany undue excitability of the spinal marrow. It may exist in the case of tetanus of centric origin, if such disease exists.

334. *Exp.*—I need scarcely revert to the phenomena of diastaltic actions, so frequently mentioned already.

335. Such phenomena in the human subject are of the most frequent occurrence. Physiological, they constitute all the actions of ingestion and of egestion. Pathological, they are observed in a thousand forms, in *spasmodic* and *convulsive* diseases.

336. They are sometimes simple. In this manner, the irritation of dentition induces flexure of the thumb into the palm of the hand, or the eyes are distorted by strabismus.

337. But they are also sometimes complex. In such a case, it too frequently happens that the muscles of '*The Neck*' are contracted upon its veins, inducing intra-cranial and intra-spinal congestion. It too frequently happens that the larynx is closed, and that efforts of expiration are excited, adding to this congestion. But of this topic, which is of vast extent and importance, I have treated fully elsewhere.

338. *Exp.*—If we take a frog, and apply the minutest quantity of strychnine in solution in pure water over the cutaneous surface, the animal is speedily affected with extreme excitability of the spinal centre. The slightest stimulus applied to the skin induces general tetanoid spasm.

339. A *similar* state of morbid excitability exists in hydrophobia, and, with certain peculiarities, in the cases of dentition, uterine irritation, &c. There is not only excitation, but undue excitability.

340. *Exp.*—If, having removed the head in a frog, we denude a nerve and irritate it by a probe or forceps, or by the galvanic current, we observe *sudden* contractions of the muscles and movements of the limbs to which this nerve proceeds.

341. The irritation of a muscular nerve in the limb after amputation, in the human subject, produces the same phenomenon. A *similar* phenomenon takes place, in the face for example, when the facial nerve has been affected by *blight*, or a current of air. In the rarer case, *spasm* is the first and only affection. In the more common, paralysis is first observed, and afterwards *spasm*, as recovery takes place; the severer form of the malady inducing catalysis of the nerve; the less severe, mere irritation. There is frequently a tendency to spasm in the limb previously affected by rheumatism.

342. A tumor or lesion of a muscular nerve, if the source of irritation, and not of catalysis, is attended by spasm.

343. *Exp.*—If, in a frog, the head being removed, we denude a lumbar nerve, spasms occur as the nerve becomes dry.

344. If, instead of exposing the nerve to dry, we pass the galvanic current along it, muscular contraction is observed at each ‘making’ and ‘breaking’ of the circuit; and if these be effected rapidly, the limb assumes the form of *tetanus*. If the current be continued for a certain time, and then be removed, the electrogenic state is induced; and as this is *discharged*, a similar tetanoid state is observed.

345. In these cases we merely observe the effects of various kinds of *stimulus*. The principle is the same—irritation of a muscular nerve.

346. I need not point out the application of these observations to the *Diagnosis* of the diseases of the nervous system.

SECTION VIII.

THERAPEUTICS OF THE DIASTALTIC SYSTEM.

§ I.—*Diastaltic Action of Remedies.*

347. THE Therapeutics of the Diastaltic Nervous System present a new object of study. One principle prevails throughout—the stimulus of an *Esodic Diastaltic Nerve*.

348. Each stimulus is characterized by another principle—that of *Difference* and repetition.

349. The principal stimulus is temperature — the application of some object higher or lower in temperature than that of the part to which it is applied.

350. The case of perfect paraplegia from a cause limited to the upper part of the dorsal region, for example, is the best case for the study of the stimuli of diastaltic action.

351. When *all* sensation and *all* voluntary motion are extinct, the lower extremities are moved on the prompt application of a spoon taken out of water a certain number of degrees higher, or lower, in temperature, than that of the limbs.

352. Other stimuli, such as a puncture, or a pinch, or pulling a hair, have a similar effect.

353. The most *useful* of these measures is the sudden application of cold water. Dashing cold water on the face, or on the chest, induces a sudden inspiration. The sudden application of a cold douche on the abdomen induces contraction of the uterus, in cases of hæmorrhagy.

354. But there must be *difference* of temperature, and the phenomenon ceases on repetition, if the part itself becomes cold. In this case, I imagine that the application of water of somewhat elevated temperature would have a good effect. I have myself experienced that to descend into a cool bath, and into a bath of from 100° to 104° Fahr. is equally attended by sudden inspirations.

355. In the case of asphyxia, such a principle ought to guide us ; but experiments on the subject are entirely wanting.

356. There is one fact of great interest in this matter. It seems that the course of the effect of each stimulus is panthodic. Dashing or applying cold water on the face induces, not only an act of inspiration, but an act of deglutition, and the evacuation of the bladder, the rectum, and even the uterus.

357. Mr. Simpson observed that if, in coma, fluid were placed in the mouth and remained unswallowed, an act of deglutition was instantly excited by dashing cold water on the face. Dr. Tyler Smith observed, in a case of faintishness from uterine hæmorrhagy, that if cold water were dashed on the face, the uterus instantly contracted on his hand within its cavity.

358. This panthodic action is a general principle, and deserves to be fully investigated.

359. Dashing cold water on the thighs and abdomen sometimes induces the evacuation of the bladder or rectum. It is instructive to know that a *similar* effect is induced by the easier method of dashing cold water on the face. I think that, in some cases of difficulty in passing the

catheter, from spasm, this difficulty and this spasm might be removed together by dashing cold water on the face ; and that, in some cases of constipation, a similar effect on the rectum might be produced by the same measure.

360. It still remains to be determined fully and accurately *what* effects may be produced by the sudden *injection* of cool water, of various temperature and in various quantity, into the rectum, the bladder, and the vagina.

361. It remains to be determined too, what good results might occur from exposure of the face or other parts of the surface to a current of cool air. In sea-sickness, in syncope, and in asthma, the effect of this measure is most marked.

362. In asphyxia from drowning especially, an alternate douche or bath of warm and cold water, suddenly applied, deserves a careful trial.

§ II.—*Tonic Diastaltic Action.*

363. The actions of which I have just treated are all of the *clonic* kind. But there is an influence of external agents through the spinal centre of a distinctly *tonic* character.

364. Such are the effects of the sea-breeze on the face and on the general surface ;

365. Such are the effects of a gentle shower-bath, of sponging the surface, of sea-bathing ;

366. Such, in part too, are the effects of the country air, and of change.

367. I have already noticed the influence of the sea-breeze on the face in allaying sea-sickness, and of free exposure to a current of air in asthma.

367. The due adjustment of clothing conduces to the same effect; and a fact observed upon one of our domestic animals is of the same kind: if a horse with a rough 'coat,' in warm weather, be 'clipped,' he passes from a state of languor to one of energy, and is capable of far more work with less fatigue. The difference between good and bad 'grooming' is partly of the same kind. The tonic diastaltic and other effects of the access of the air to the surface are insured in the former case, and excluded in the latter.

368. The difference between meeting the wind and moving in the same direction, in warm weather, whether walking or riding, is extremely great, partly for the same reason.

§ III.—*Centric Action of Remedies.*

369. Centric actions, when clonic, are usually of a morbid character. The spasmodic symptoms in strangulation and in purer asphyxia, arising from counter-pressure, or congestion, or the admission of undecarbonized blood, in the medulla, are of this character.

370. But there are other centric effects from remedial agents. These are seen in their most distinct forms, produced on the frog, for example, by strychnine, and by chloroform: the excitability in the former case is extreme; in the latter, it is extremely reduced.

371. These and other agents, when they shall have been carefully tried on the human subject, may prove *remedies* in cases to which they are, from their respective properties, chiefly adapted.

372. In one case of general paraplegia of the hands and feet, *without spasm*, I gave the fiftieth of a grain of the acetate of strychnine, four times a day: the power of *writing* and of *walking* speedily returned, in a considerable degree. The amendment is still progressive.

373. Experiment demonstrates that strychnine and some other agents exert their energies on the spinal centre. There are even certain parts of this centre specially affected by some of these : strychnine itself is apt to affect the medulla oblongata and the larynx, cantharides affect the lower part of the spinal centre and the cervix vesicæ, and the secale cornutum the same part of the spinal marrow and the uterus. On these principles, cantharides and the secale are employed as important remedies.

374. These hints are sufficient for my present purpose of mere illustration.

§ IV.—*Action in Exodic Nerves.*

375. There is no remedial or physiological action in Exodic nerves, except that of their actual *use*. Such a nerve, unemployed, shrinks, and loses its powers. It is just and proper exercise that is essential to its nutrition and its energy.

376. I have a preparation of the lumbar nerves of a frog, which had lost one of its posterior extremities, doubtless by some voracious fish ; the nerve of that side had become atrophied.

377. In like manner, a nerve, separated from its connection with the spinal marrow, loses its excitor power.

§ V.—*Electricity as a Therapeutic Agent.*

378. Throughout animated nature, the proportion between stimulus and excitability and irritability is precise, but inverse. See § 99—.

379. This *Law* must be borne in mind, in the therapeutic use of stimuli, and especially of electricity. If the electric force employed be too

low, little effect will be produced ; if too high, *exhaustion* will speedily follow the application of the stimulus. See § 102. The effect is one of a *pathological* character.

380. But the effect of the electro-dynamic apparatus is unlike any thing in Nature ! It is that of a most irritant alternation of current.

381. There is a question, in reference to the application of electricity or galvanism to the animal frame, of the most intense interest. A current cannot pass without inducing an electrogenic state. This, in muscle and humid nerve, is a state of less susceptibility to the *same* current, but of unimpaired susceptibility to the *opposite* current. The current may be applied and changed, with this effect, repeatedly. It has been designated the 'alternative Voltaique,' from its discoverer, as seen in the lower animals. Its existence in the human subject I have myself observed. The fact must be taken into account, in judging of the effect of galvanism as a *test* of irritability.

382. A similar remark applies to the effect of repeated contraction of the muscle from *any* cause. Its irritability is diminished for a time. This fact must also be borne in mind, in employing galvanism as a *test* of the irritability of the muscular fibre.

383. What is the most probable good or therapeutic effect of galvanism ? It may excite the failing *heart* in asphyxia or syncope, and the *uterus* in inertia of this organ. It may *exercise* the nervous and muscular system, and so restore them, in some measure, from atrophy and debility. It is, in *this* manner, useful in the paralysis remaining after the organic cause of the disease may have been removed. It may be useful in paroxysmal paralysis, in paralysis of the facial nerve from cold, in some hysteric forms of paralysis, &c.

384. There is a question, I think, whether, in asphyxia, the current of galvanism or electricity might be efficaciously passed along the nostril,

or across the medulla oblongata, or through the lungs, or diaphragm, or intercostals, by means of needles or otherwise.

385. The whole subject requires careful investigation, and separation from the domain of quackery.

386. The kind, and degree, and direction of the current, and its physiological, electrogenic, pathological, and therapeutic effects, require to be accurately determined.

§ VI.—*Opinions of Signor Matteucci.*

387. I cannot agree with Signor Matteucci in his views on this subject. That philosopher observes—

388. “ Nous avons vu également que si les nerfs d'un animal vivant sont soumis au passage du courant électrique, renouvelé à de courts intervalles, on éveille dans cet animal des contractions tétaniques. En prolongeant pendant un certain temps ce traitement, les nerfs perdent entièrement leur excitabilité.

389. “ Voici donc des faits qui, indépendamment de toute idée théorique, ou de toute hypothèse sur la force nerveuse, peuvent nous guider dans l'application thérapeutique du courant électrique aux paralysies. En effet, nous pouvons admettre que dans quelques cas de paralysie, les nerfs du membre malade sont altérés d'une manière analogue (?) à celle qui y serait produite par le passage continu d'un courant électrique. Nous avons vu que pour rendre à un nerf qui a perdu par le passage du courant son excitabilité pour ce courant, il faut agir sur lui avec un courant dirigé en sens contraire. De même, pour faire cesser la paralysie, on devra faire passer un courant en sens contraire à celui qui aurait pu la produire. On voit par là que nous supposons que la paralysie qu'on doit soumettre au

traitement électrique est de mouvement ou de sensibilité séparément. Ainsi, pour une paralysie de mouvement, c'est le courant inverse qui sera appliqué, tandis que pour une paralysie de sentiment, on devra appliquer le courant direct.

390. " Dans le cas de paralysie complète, il n'y a plus aucune raison pour se décider à appliquer le courant plutôt direct qu'inverse*."

391. When the currents of sensation and of voluntary motion are shewn to be identical with a current of galvanism, and paralysis with the condition produced by a continuous current of galvanism, then this reasoning will apply—but not till then.

392. The same remark applies to the opinion contained in the following paragraph :

393. " Une autre maladie, pour laquelle on a proposé l'application du courant électrique, c'est le tétanos. Je crois avoir été le premier qui ait tenté cette application sur l'homme. Voici les données sur lesquelles on peut se fonder. Nous avons vu que lorsque le passage du courant électrique, dans les nerfs d'un animal vivant ou récemment tué, est renouvelé plusieurs fois de suite, à de courts intervalles de temps, les membres restent tendus par des contractions tétaniques. Nous savons également qu'au contraire les membres sont paralysés, quand le passage du courant est prolongé sans interruption pendant un certain temps. On voit par là que les effets du passage du courant électrique sont tout à fait différents, suivant qu'il est continué ou interrompu. Il était donc naturel de penser que le passage continu du courant électrique dans un membre tétanisé aurait détruit cet état, en amenant celui de la paralysie†."

394. Traumatic tetanus, and, not less, the tetanoid state produced by strychnine, are totally different in their *nature* from the tetanoid state pro-

* Traité des Phénomènes Electro-Physiologiques, p. 266.

† Op. cit. p. 269.

duced in denuded nerves by a continuous galvanic current, and cannot be compared with it, except to be contrasted and distinguished.

395. Signor Matteucci adds—"Tous les poisons narcotiques, tels que l'opium et la noix vomique, donnés aux grenouilles, commencent par stupéfier ces animaux, ensuite les surexcitent, et enfin quelque temps avant la mort, on les voit pris de convulsions tétaniques très-violentes. Si alors on fait passer dans ces animaux pris dans ce dernier état, un courant électrique d'une certaine intensité, on voit, en le prolongeant, cesser la roideur de leurs membres, et les secousses disparaissent. Ces grenouilles meurent après un certain temps, mais sans donner de signes de tétanos. Afin de rendre moins forte la contraction qui a lieu au commencement du courant, il vaut mieux employer le courant inverse*."

396. But it is obvious that, in this case, the animal was exhausted and killed, by the narcotic or the galvanism, or both, and not cured.

397. Sig. Matteucci adds—"L'application du courant électrique sur un malade atteint de tétanos, que j'ai publiée dans la *Bibliothèque universelle*, mai 1838, me semble prouver la réalité de ces conclusions théoriques. Le malade, pendant qu'il était soumis au courant électrique, n'éprouvait plus de secousses violentes comme auparavant; il pouvait ouvrir et fermer la bouche; la circulation et la transpiration paraissaient se rétablir. Malheureusement ces signes d'amélioration dans son état ne furent que passagers; la maladie était occasionnée et entretenue par la présence de corps étrangers dans les muscles de la jambe†."

398. Now the case of tetanus from strychnine is an affection *not* of the *nerves*, but of the spinal marrow; as that of traumatic tetanus is *not* of the exodic nerves, but of the esodic nerves and of the spinal marrow. There is neither identity, nor even similarity or analogy, between these

* Op. cit. p. 270.

† Ibid. p. 271.

cases and the electrogenic effect induced in exodic or muscular nerves to which Sig. Matteucci refers.

399. I think too, that, in Sig. Matteucci's experiments with galvanism on the frog tribe, the effects are frequently *pathological*, the current being of too high a force for *physiological* results. It is a mistake, for instance, to suppose that the *direct* current passed along a denuded nerve uninterruptedly for a time, does *not* induce the condition which produces tetanoid spasm on its removal. It is a mistake to suppose that the *muscles** are not subject to the 'alternative Voltaïque.'

400. I repeat, with earnestness, that, in all experiments of this kind, the due and physiological relation between the force of the stimulus and the excitability of the nerve and the irritability of the muscle,—that *Law* of the animal œconomy, pervading all its series and all its stages, to which I have adverted in § 99,—should be strictly observed.

401. In the trials with electricity or galvanism as a remedy in the human subject, this and other *physiological* principles have been entirely overlooked. This observation is especially true in regard to the employment of galvanism as a *test* of irritability.

§ VII.—*Electrogenic Effects on the Diastaltic System.*

402. I recently read a paper on the present subject before the Royal Society. Even to the meaning of the term adopted, it was misunderstood. It is published in the *Edinburgh New Philosophical Journal*, for 1848. The following are the principal results of my inquiry :

403. 1. In order to adapt the force of the stimulus to the excitability and irritability of the subject (the frog), I employed a simple arc of zinc

* Op. cit. p. 228.

and of silver, or several such arcs arranged as a '*couronne de tasses*' with pure water.

404. 2. The frogs were variously prepared, but chiefly as represented in *figure 7*.

405. 3. When the arrangement was such as to allow a current to pass along the *denuded* lumbar nerves, muscular contraction occurred on 'making' the circuit; no such phenomenon being observed, after a second or two, during its *continuance*.

406. 4. On 'breaking' the circuit after a time, the limb to which the nerve proceeds is thrown into a state of rigid *persistent tetanoid* spasm.

407. This effect is produced by either the *direct* or the *inverse* current; more speedily perhaps, but also more transitorily, by the direct, than the inverse.

408. If the nerve, instead of being denuded, is surrounded by *humid* tissues, this effect is not produced.

409. If the denuded nerve be allowed to become *dry*, movements in the limb are observed without the application of the galvanic current.

410. If the undenuded nerve or the muscle be subjected to the galvanic current, an electrogenic state of another kind is produced—the '*alternative Voltaique*;' the limb ceases to be moved on breaking and repeating the *same* current, but is agitated by *changing* the direction of the current, and this repeatedly. The mere muscle presents this phenomenon.

411. I succeeded, after repeated trials, by subjecting the *spinal marrow* itself to the galvanic current, in producing the electrogenic state in this organ with the same *tetanoid* phenomena, on 'breaking,' both by the *direct* and the *inverse* current.

412. I also succeeded in obtaining a distinct electrogenic state of the *esodic* nerves.

414. The case in which the spinal marrow is placed in the electrogenic state resembles that of spinal arachnitis, the spinal centre being subjected to continued *irritation*. That in which the esodic nerves are subjected to the same condition, most nearly resembles the case of tetanus; but of a tetanus without the augmented excitability of the spinal centre which characterizes real tetanus.

415. In fact, I have not been able to produce a perfect *type* of traumatic tetanus in my experiments—the effect of strychnine wanting the irritated condition of the esodic nerve, and the electrogenic state of the esodic nerve wanting the undue excitability of the spinal centre,—both of which co-exist in tetanus.

416. In the course of these experiments, of which I have given a brief sketch, and which occupied the evenings of a winter, I again *analysed*, as it were, the diastaltic nervous system, acting distinctly on *each* and *all* its parts, esodic, centric, and exodic; producing its phenomena in *all* directions, anodic, diodic, cathodic; and confirming all that I have stated on this subject in the earlier part of this volume.

417. How darkly do those persons proceed, who, without previous study of the nervous and muscular systems, and their *relation* to galvanic and other stimuli, venture at once to subject the human subject to the violence of the electro-dynamic and other similar apparatus! On ‘making’ and ‘breaking’ the galvanic circuit, there is reason to conclude that the current is reversed. How rapidly is such reversion *repeated* in the use of these instruments! How unlike any thing in Nature, and how unlike any event occurring physiologically in the animal frame and œconomy!

418. We want well-divided, cautious, and sustained experiments on this subject, made by the *physiologist*, and applied by the *physician*.

SUPPLEMENT I.

STRYCHNINE IN RELATION TO THE DIASTALTIC SYSTEM.

419. IN this place I adduce a paper of mine recently published in the "*Comptes Rendus*" of the Institute of France :

" Comparaison entre les effets tétanoïdes des états électrogéniques, et ceux de la strychnine, de la narcotine, etc.*

420. Si l'on fait traverser la moelle épinière ou les nerfs lombaires de la grenouille, mis à nu et parfaitement isolés, par un courant voltaïque faible, mais continu, et qu'au bout de dix à vingt minutes on éloigne l'appareil voltaïque, on voit sur-lechamp se produire un état tétanoïde très-énergique des membres inférieurs.

421. Si l'on place une grenouille dans une solution d'acétate de strychnine très faible, pendant le même espace de temps, il survient aussi un état tétanoïde des membres inférieurs.

422. Ces états tétanoïdes sont-ils identiques dans leur mode d'action, ou bien sont-ils tout à fait différents à cet égard comme ils le sont dans leur source ; et, si cette différence existe, y en a-t-il quelque application utile à en faire à la science de la médecine ? Telle est la question que je me propose de discuter dans le Mémoire que j'ai l'honneur de présenter à l'Académie.

* From the "*Comptes Rendus*," for June 14, 1847, p. 1054.

423 Il n'est pas nécessaire, depuis l'ouvrage classique de M. Flourens sur le système nerveux, de rappeler les faits qui prouvent qu'une irritation quelconque de la moelle épinière ou des nerfs musculaire produit des contractions des muscles situés au-dessous. Il est plus essentiel de citer les faits qui démontrent qu'une irritation portée sur certains nerfs *incidents* provenant des tissus cutanés, muqueux et autres, agit par le centre spinal sur des nerfs spéciaux qui sont liés mystérieusement par ce centre avec les premiers, et produit ainsi des contractions dans le système musculaire. Les premiers faits sont des exemples d'actions *directes*; les seconds, d'actions *réfléchies*.

424. Y a-t-il quelque ressemblance, quelque parallélisme entre les phénomènes des états tétanoïdes *électrogéniques* et ceux que produit la strychnine? C'est encore une question qu'il semble utile d'examiner.

I.—*De l'état électrogénique de la moelle épinière.*

425. Dans un Mémoire récemment lu à la Société royale, j'ai décrit, avec tous leurs détails, une série d'expériences concernant les états tétanoïdes produits en exposant la moelle épinière, les nerfs musculaires, et, en quelque sorte, les nerfs incidents, à un courant voltaïque. Cet état des nerfs est ce que j'appelle *état électrogénique*.

426. Je n'ai qu'à observer ici que cet état électrogénique des nerfs, et l'état tétanoïde des muscles, qui en est l'effet, persistent d'une manière continue jusqu'au moment où ils cessent entièrement. Il n'est pas besoin de renouveler les excitations; il n'y a pas de paroxysmes.

427. J'ai reconnu plus récemment que ni le courant voltaïque, ni l'état électrogénique ne s'opposent aux actions réfléchies, effet des excitants extérieurs. Ces actions dépendent donc d'un principe moteur ou excito-

moteur tout à fait différent de l'électricité ; on bien il en faudrait conclure que deux états provenant d'un seul et même principe peuvent traverser sans interférence les mêmes tissus. L'état électrogénique des nerfs est actif et direct, et continu dans son influence sur le système musculaire : c'est de l'*excitation*. Et ce n'est pas, je crois, comme l'imagine mon excellent ami M. Matteucci, de l'*excitabilité* augmentée*. Nous allons voir quelle différence et même quelle opposition existe entre cet état et celui provenant de la strychnine, tout tétanoïdes qu'ils soient tous deux.

II.—*De l'état tétanoïde du système spinal, effet de la strychnine.*

428.—L'état du système spinal sous l'influence de la strychnine suit une loi d'action totalement opposée à celle que nous venons de considérer. Ici pas d'activité, pas d'action continue. Ce n'est plus de l'*excitation*, c'est de l'*excitabilité* augmentée. Il faut des excitants ; les actions ne sont plus directes, elles sont réfléchies. C'est ce que font ressortir, ce me semble, les expériences suivantes :

429. *Première expérience.*—J'ai mis une grenouille (*Rana temporaria*) dans une solution très-faible d'acétate de strychnine, de manière à produire lentement l'état tétanoïde : le premier phénomène a été le passage du mouvement volontaire à un spasme tétanoïde de tous les membres, accompagné d'une expiration forte et coassante. Cet état de spasme a bientôt cessé, et lorsque toute excitation extérieure a été écartée, les yeux sont redevenus proéminents, la respiration s'est faite normalement, les membres supérieurs et inférieurs étaient parfaitement souples et constamment fléchis.

430. La grenouille semblait éviter à dessein tout mouvement volon-

* Leçons sur les phénomènes physiques, etc. 1847, p. 242.

taire. Les mouvements de la respiration offraient quelquefois des signes d'un état tétanoïde, état qui était sans doute excité dans ce cas, comme dans le cas de mouvement volontaire, par le frottement de la peau contre la table ou contre la plaque de verre sur laquelle l'animal était posé ; car la moindre excitation extérieure, le léger contact d'une plume, le plus léger contact du doigt, la plus légère secousse de la table ou du plancher, produisait un état de rigidité et de spasme tétanoïde, les yeux étant retirés, la respiration suspendue, les membres affectés de roideur tétanique.

431. *Deuxième expérience.*—J'ai placé un crapaud (*Bufo vulgaris*) dans une solution d'acétate de strychnine faible. Il a fallu plus de temps pour la production de l'état tétanoïde pour ce crapaud que pour la grenouille ; mais alors les phénomènes ont été, à quelques circonstances près, les mêmes. Le crapaud faisait des mouvements volontaires continuels, jusqu'au moment où l'état tétanoïde se manifestait ; et cet état était reproduit lorsqu'on passait quelque objet devant les yeux de l'animal, effet d'émotion que je n'ai pas observé sur la grenouille.

432. L'état tétanoïde produit par la strychnine paraît limité au système spinal. Le cerveau, le système ganglionnaire n'est pas impliqué. Il y a des mouvements volontaires dans le crapaud jusqu'au moment du développement du tétanos ; le cœur ne cesse pas de battre et la circulation continue dans les capillaires, comme je l'ai vu dans une expérience dans laquelle j'ai divisé la moelle épinière près de l'occiput, étalé les membranes de la patte sous le microscope, et observé l'état de la circulation dans les vaisseaux capillaires.

433. *Troisième expérience.*—J'ai divisé la moelle épinière près de l'occiput, et appliqué une solution d'acétate de strychnine sur la surface cutanée. Dans cinq à dix minutes, l'état tétanoïde était établi, la respiration forte et coassante s'était fait entendre, les extrémités antérieures (c'était une grenouille mâle, dans le printemps) se courbaient fortement

sur la poitrine, les extrémités postérieures s'étendaient tétaniquement. J'ai ôté les téguments de la partie postérieure de l'animal ; les membres postérieurs sont devenus de suite tout à fait mous et fléchis. Plus de spasme, plus de tétanos, même lorsqu'on pinçait les membres dépourvus de leur peau, et en même temps des origines de leurs nerfs incidents excitomoteurs. Les extrémités antérieures étaient dans l'état ordinaire, et lorsqu'on les irritait, il y avait tout à coup rigidité des membres postérieurs.

434. *Quatrième expérience.*—Dans une autre expérience, j'ai séparé les téguments de la partie antérieure d'une grenouille, les laissant sur les membres inférieurs. Plus d'état tétanoïde alors, en irritant les tissus dénudés des parties ou extrémités antérieures, tandis que la moindre irritation de la peau des extrémités antérieures produisait des spasmes énergiques.

435. Toutes ces expériences furent répétées avec les mêmes résultats. Dans les cas où la moelle épinière avait été divisée et la peau enlevée, il y avait tétanos à l'instant si l'on touchait la partie de la moelle où la section avait été faite, ou si l'on laissait tomber la grenouille sur la table.

436. *Cinquième expérience.*—Dans une grenouille affectée de l'état tétanoïde produit par la strychnine, j'ai divisé les nerfs lombaires près de la moelle épinière. Le tétanos a cessé instantanément dans les membres inférieurs.

437. Cette influence de la strychnine sur le système nerveux est donc limitée à la moelle épinière comme centre spinal. Les nerfs n'en sont pas susceptibles : autre circonstance qui distingue l'état tétanoïde de la strychnine d'avec l'état électrogénique.

438. *Sixième expérience.*—J'ai soumis trois grenouilles à l'influence de la strychnine : dans une grenouille, le système nerveux était entier ; dans les deux autres, la moelle était divisée près de l'occiput. Toutes étaient susceptibles des excitations extérieures.

439. J'ai placé la première de ces grenouilles dans une petite quantité d'eau, de manière à ce qu'elle pût respirer, et je l'ai bien préservée de toute excitation. Le lendemain elle était bien vivante et parfaitement libre de tout état tétanique.

440. J'ai mis une des deux autres, dont la moelle épinière était divisée, dans de l'eau fraîche, de la même manière, et je l'ai placée également à l'abri de toute excitation et dans une atmosphère pure et froide. Le lendemain, cette grenouille était aussi bien vivante, mais toujours affectée de tétanos.

441. La troisième grenouille, dans laquelle la moelle épinière avait aussi été divisée, près du crâne, a été excitée incessamment au moyen d'un stylet d'argent ordinaire, passé et repassé sur la surface cutanée : dans deux minutes elle est devenue très-faible, et dans cinq minutes elle était absolument morte.

442. *Septième expérience.*—J'ai soumis deux grenouilles à l'influence d'une solution d'acétate de strychnine faible, ayant préalablement divisée la moelle près de l'occiput. Toutes deux sont devenues tétaniques.

443. J'en ai excité une, que paraissait la plus énergique, d'une manière continue, de façon à produire un tétanos presque constant. Bientôt la susceptibilité sous les impressions, et les contractions des membres s'affaiblirent ; après un espace de temps assez court, cette grenouille était très faible, pendant que l'autre était vivace comme auparavant. J'ai laissé la grenouille, ainsi affaiblie, en repos. Après un certain intervalle, elle s'était notablement rétablie.

444. *Ces expériences nous apprennent, ce me semble, ce qu'il faut faire, ce qu'il faut éviter, dans le traitement de certaines maladies, le tétanos traumatique, l'hydrophobie. Nos malades meurent s'ils sont excités ; pourraient-ils survivre s'ils étaient préservés absolument de toute excitation extérieure ?*

445. J'ai déjà dit que dans les grenouilles affectées par la strychnine,

et dans lesquelles la moelle n'était pas divisée, la respiration n'est pas suspendue, excepté dans les moments du tétanos. L'expérience suivante prouve que l'état tétanoïde de la grenouille produit par la strychnine ne cause pas l'expulsion des œufs.

446. *Huitième expérience.*—Une grenouille femelle dont les oviductes étaient pleins d'œufs, fut soumise à l'influence de l'acétate de strychnine. Elle fut mise à l'abri des excitations, et elle s'est parfaitement rétablie. Quelques jours plus tard, j'observai qu'une quantité d'œufs avait été expulsée*.

447. Ainsi la respiration n'est pas nécessairement suspendue ; les œufs ne sont pas nécessairement expulsés, dans l'état d'éréthisme produit par la strychnine. Si la strychnine était administrée à plus haute dose, les phénomènes pourraient être différents. L'excitabilité étant extrême, le tétanos serait constant, la respiration serait suspendue, et de deux manières la mort serait prompte ; il est probable que les œufs seraient expulsés.

448. Ces expériences ont été faites sur des Batraciens. Quelles seraient les différences si elles étaient faites sur d'autres animaux ? Cette question, pleine d'intérêt, est d'une trop grande étendue pour que je la traite à cette occasion. Je me permettrai seulement de donner une seule expérience sur un animal vertébré et à sang chaud.

449. *Neuvième expérience.*—J'ai mis la quarantième partie d'un grain d'acétate de strychnine, en solution, dans la gueule d'un petit chat âgé d'une semaine ; dans un instant le larynx s'est resserré, et l'animal est mort d'asphyxie.

450. C'est à cette contraction du larynx qu'est due la mort presque subite produite par ce poison. C'est à cette même contraction qu'il faut

* Le célèbre Dupuytren a observé un cas de tétanos dans lequel le fœtus a été retenu dans l'utérus.

attribuer bien des événements fâcheux dont les médecins sont témoins dans leur pratique.

451. *Dixième expérience.*—J'ai mis une grenouille dans une solution d'acétate de morphine, elle est devenue simplement inerte et immobile. Dans quelque position gênée qu'on la posât, elle ne se remuait pas.

452.—*Onzième expérience.*—J'ai mis quelques gouttes d'une solution d'acétate de narcotine dans la gueule d'une grenouille, et j'ai placé l'animal dans une solution semblable, mais faible. Le premier signe de l'influence de cet agent consiste dans des mouvements alternatifs d'extension et de flexion des deux membres inférieurs, mouvements rapides et énergiques ; le second signe est un état tétanoïde des quatre extrémités, en avant et latéralement, bien différent de la tension rigide produite par la strychnine, et non moins spéciale et remarquable ; le troisième, une rétraction des yeux ; le quatrième, la suspension de la respiration, d'où résulte le cinquième, c'est-à-dire des paroxysmes tétaniques, en apparence sans excitation extérieure. Ces derniers phénomènes sont probablement cause et effet ; la respiration étant suspendue, l'excitant intérieur du mouvement respiratoire s'accumule et devient cause efficiente d'une action excitée, réfléchie, spasmodique.

453. *Douzième expérience.*—J'ai enlevé le cerveau d'une grenouille et étalé la membrane des pattes sous le microscope ; j'ai introduit alors sous la peau une solution de *digitaline*. La circulation, dans les vaisseaux capillaires, a disparu graduellement, tandis que les actions excito-motrices restaient énergiques.

454. De ces dernières expériences nous concluons que, des principes actifs de l'opium, la morphine affecte le cerveau exclusivement, et la narcotine la moelle épinière d'une manière toute spéciale. La digitaline agit sur le système ganglionnaire.”

SUPPLEMENT II.

§ I.—*Prof. J. Reid's Work.*

455. SINCE the date of the publication of my last 'Memoir,' our profession has had to deplore the loss of Prof. J. Reid, one of its brightest ornaments. I quote with peculiar pleasure the following paragraphs from this gentleman's recent republication of his Papers, in a volume entitled *Physiological Researches*.

456. Treating of the *glosso-pharyngeal nerve*, Prof. J. Reid observes—

457. "Mechanical or chemical irritation of this nerve before it has given off its pharyngeal branches, or of any of these branches individually, is followed by extensive *muscular movements* of the throat and lower part of the face.

458. "The muscular movements thus excited, depend, not upon any influence extending downwards along the branches of the nerve to the muscles moved, but upon a *reflex action*, transmitted through the central organs of the nervous system." P. 90.

459. "Mechanical or chemical irritation of the nerve, immediately after the animal has been killed, is not followed by *any muscular movements*, when sufficient care has been taken to insulate it from the *pharyngeal branch of the par vagum*. And we here again observe an important difference between the movements excited by irritation of the *glosso-pharyngeal* and those of a motor nerve. For while the movements produced by the

irritation of the *glosso-pharyngeal* are arrested as soon as the functions of the central organs of the nervous system have ceased, those from irritation of a motor nerve, such as the *pharyngeal branch of the par vagum*, continue for some time after this, and when all connection between it and the *medulla oblongata* has been cut off." P. 91.

460. When stating the results of his experiments on the pneumogastric nerve, Prof. J. Reid observes—

461. "When any irritation is applied to the mucous membrane of the larynx in the healthy state, this does not excite the contraction of the muscles that approximate the arytenoid cartilages, by acting directly upon them through the mucous membrane; but this contraction takes place indirectly, and by a reflex action, in the performance of which the superior laryngeals act as the *sensitive* (!) or afferent nerves, and the inferior laryngeals as the motor or efferent nerves. It is also probable that those branches of the inferior laryngeal distributed in the muscular fibres of the *trachea* are motor.

462. Prof. J. Reid adds—"The œsophageal filaments of the *vagus* are partly afferent and partly efferent nerves. In some animals, as in the rabbit, the section of the *vagi* in the neck is followed by arrestment of the passage of the food along the œsophagus, not from destroying the contractility of the muscular fibres of the œsophagus, but by breaking the continuity of the nervous circle necessary for the accomplishment of all reflex actions." P. 251—252.

463. Dr. J. Reid has some valuable experiments and observations on the *value* of the pneumogastric as the principal excitor of inspiration. My reader may turn to his admirable work, pp. 185—, 285—. I have only space for the following extract:

464. "We have detailed various experiments to prove that though the *vagi* are the most important of the afferent or excitor nerves, which convey

those excitations to the medulla oblongata which produce the respiratory muscular movements, other cerebro-spinal nerves possess this property, though in a much feebler degree."

465. It will be obvious to the attentive reader, how little progress even Prof. J. Reid had made in the knowledge of the real *Principle of Action* in these various phenomena, whilst his phraseology is certainly a little 'uncouth'; but, I believe, few have excelled him in the exactness of his experiments, and the value of his results. Prof. J. Reid's view was still that of Prochaska—'impressionum *sensoriarum* in motorias reflexio'—and of Prof. J. Müller, who translates this idea into German, 'der Reflexion in den Bewegungen nach *Empfindungen*.'

§ II.—Of Shock.

466. I think we have been under considerable misapprehension in regard to *Shock*.

467. If the spinal marrow be divided in the frog, just below the occiput, there are, for a very short time, no diastaltic actions in the lower extremities. This phenomenon is doubtless the effect of shock. The diastaltic actions speedily return.

468. If, in a frog, we destroy the spinal marrow, without any special precautions to prevent hæmorrhagy, the power of the heart is so diminished that the circulation of blood in the web or the lung is annihilated.

469. This phenomenon was also ascribed to shock. But this view is an error. If the measure described in § 162, to prevent hæmorrhagy, be carefully adopted, the circulation continues, although it still gradually subsides, and in due time ceases altogether. The cessation of the circulation, previously ascribed to shock, is in reality owing to *loss of blood*.

470. If, when we have divided the spinal marrow, and given time for the restoration of the diastaltic actions, we crush one limb, by repeated blows of a hammer, from below upwards, we produce little or no effect on the diastaltic actions, or on the circulation, in the other limb. There is *no* appearance of *shock*.

§ III.—Of *Facial Paralysis*.

471. If I puncture a nerve with the point of a needle, I irritate that nerve; if I compress the nerve by means of the same needle, I abolish its function altogether.

472. If the trifacial nerve be irritated by the presence of a grain of sand between the eye and the eye-lid, the eye-lid is violently closed. If the same nerve be divided, as in the valuable experiments of M. Magendie, and possibly in certain cases of disease, it becomes *in-excitabile*, and its power of inducing closure of the eye-lid, on the application of a stimulus, is abolished.

473. If the spinal centre be irritated, *spasm* is the consequence; if its function is abolished, by exhaustion, or by lesion, *paralysis* is the result. If irritation and partial abolition of function be combined, the case is one of *spasmo-paralysis*.

474. These facts are the physician's guide in practice, in the choice of his remedies, and are the most important, in this point of view, we possess.

475. I have thus presented my reader with a view of irritation and of abolition of function, in an esodic nerve, and in the spinal centre. I proceed to introduce a brief view of such morbid affection in an exodic nerve — *the Facial* — by way of mere illustration of a subject which I reserve for full discussion in a future work.

476. Affection of the facial nerve is of *three kinds*, and assumes *three forms* :

477. The first is limited to the exterior branches of the facial nerve ;

478. The second has its origin within the cranium, and usually affects the portio mollis as well as the portio dura, adding deafness to the facial paralysis ;

479. The third is, as yet, I believe, unrecognized, and consists in the *extension* of the disease along the facial nerve, or its neurilemma, into the cavity of the cranium, affecting the membranes, or the cerebrum itself ; it is not necessarily combined with deafness.

480. In all these cases there may be the combination of spasm with the paralytic affection. In the last there may be even convulsive or epileptic affection.

481. It is obvious, from these observations, that facial paralysis is not always so free from danger as we should imagine, from the description given of it by Sir Charles Bell and other writers.

482. The most common case of facial paralysis is that which is the effect of exposure to a current of wind,—at an open window,—or in the open air when the wind is bleak.

483. This exposure induces a peculiar condition of the nerve. It may, by acting on the nervous matter, induce paralysis directly ; as a similar influence, applied to the trifacial, induces numbness or loss of sensibility. But it may induce inflammation of the neurilemma of the nerve ; and this, by its tumefaction, may so compress the nervous matter as to induce paralysis.

484. In this case, a singular effect is observed when the inflammation subsides. The tumefaction and consequent compression being less, the nervous matter is rather *irritated* than *compressed*, and the paralysis is replaced, in a greater or less degree, by spasmodic affection.

485. The affection sometimes appears to have been transferred to the opposite side of the face ; for, whilst the case was paralysis, the face was drawn to the unaffected side ; but when it becomes spasm, it is drawn to the affected side.

486. Considerable singularity of action is also observed : the orbicularis, which was simply paralysed at first, and incapable of closure, is now distorted in its partial action on attempting to close the eye.

487. With this spasmodic action there is a peculiar stiffness of the muscles of the face, which were merely flaccid before.

488 Facial paralysis of intra-cranial origin usually depends on disease of the bones or membranes, as nodes, or caries, tumors, abscess, &c.

489. Usually, as I have said, the portio mollis and the hearing are injured, with the portio dura and the action of the muscles of the face.

490. There may also be other symptoms, of the cerebral or spinal systems, arising from the influence of the disease on other tissues or other nerves : such as ear-ache, noises, head-ache, and spasmodic and paralytic affections of the limbs.

491. In one case there was caries of the petrous portion of the corresponding temporal bone. In another there was circumscribed softening of the corresponding lateral lobe of the cerebellum : there were ear-ache, deafness, and paralysis of the facial nerve ; and the patient sank rather suddenly—the medulla oblongata doubtless becoming involved.

492. It is obvious that, in such cases, the symptoms may be at first simple enough, but may become complicated ulteriorly ; and that our prognosis should be cautious.

493. Miss —, aged 38, was exposed in an open carriage to a “ keen Scotch wind,” eight years ago. For five years the case was one of simple facial paralysis of the right side. Afterwards other symptoms were superadded ; as pain of the head, a little loss of memory, incapacity for attention.

494. The affection of the face became spasmodic, and was conjoined with occasional attacks of spasm of the right side of the neck; with these there was a distended state of the veins of the neck, which, to use her own expression, appeared of ‘*the size of a finger.*’

495. The right side of the tongue became affected, with a sense of numbness of the fingers of the right hand.

496. It is obvious, from this recital, that an affection, at first external in the facial nerve, had become intra-cranial, with symptoms not a little threatening serious cerebral or spinal affection.

§ IV.—*Of Cerebral and Spinal Diseases.*

497. The symptoms of cerebral disease, when that disease is *limited* to the cerebrum or cerebellum, are *limited*, in their turn, to abnormal conditions of the cerebral or psychical functions: these may be—1, abnormal *sensations*—headache, vertigo, a sense of confusion, insensibility, &c. 2, morbid states of the *Intellect*—delirium, stupor, oblivium, &c. 3, morbid conditions of *Sleep*—vigilia, stupor, coma, &c. 4, morbid affections of the *special Senses*—blindness, flashes, muscæ, &c.; deafness, tinnitus, the noise of a cataract, &c.; loss of smell, the odour of musk, &c.; loss and morbid affections of the taste; morbid states of touch—numbness, the sense of ‘pins and needles,’ of aura; &c. 5, morbid affections of *Volition*—paralysis, &c.; 6, and lastly, the *Absence* of acute pain and of spasm.

498. But if, on the contrary, the disease be *not* limited, in itself, or in its effects, to the cerebrum or cerebellum,—if, by contact, or by counter-pressure, its influence extends to the intra-cranial membranes, or the intra-cranial nerves, or to the medulla oblongata or spinalis,—acute pain, spasm, rigidity, or convulsion, is superadded.

499. Or if the spinal system be involved by diastaltic irritation from distant membranes, *similar* effects may be observed, and there may be—

1. *Paroxysmal Apoplexy, or Paralysis, or Mania, or Crime*; or
2. *Nutation of the Head, or transitory Paralysis of the Articulation, of the Fingers in writing, &c.*; or
3. *Epileptoid Affection*—of cerebral or spinal character—according as the cerebrum or medulla oblongata may be affected.

500. The muscles of '*The Neck,*' the chief link of the chain between the source of irritation and the congestion of the cerebrum or medulla oblongata, are abnormally contracted.

501. The absence of spinal symptoms in diseases limited to the cerebrum, as pure hemiplegia*, and of cerebral symptoms in diseases limited to the spinal centre, as tetanus, is most important in the *Diagnosis*; whilst the addition of secondary symptoms to those of the system primarily affected, are facts of incalculable value in the establishment of a simple or of a complicated affection.

502. With these facts in our mind, the records of medicine and surgery must be examined, and clinical cases must be observed,—anew; and the structures at the *base of the Cranium* should form a special object of study. And as, in diseases of the spinal system, the cerebrum is only affected through the medium of '*The Neck,*' this region becomes an important object of attention.

§ V.—*Nerves and Muscles of 'The Neck.'*

503. I cannot close this little volume without adverting once more to the singular disposition of the *nerves* which are the principal agents in

* There is an exception to this rule: contraction of the fingers occurs in chronic pure hemiplegia, from the tonic physiological action of the spinal marrow, in the long-continued absence of volition.

inducing those *muscular* phenomena in the *Larynx* and in ‘*The Neck*,’—*on which all Epileptoid and some other paroxysmal maladies essentially depend.*

504. The constrictors of the larynx, the platysma myoides, the cleido-mastoid and trapezius, the omo-hyoid, with the splenii, &c. &c.—for I take no limited view of this subject—are the principal *muscles* called into abnormal action in this singular condition—a condition which, as first observed or appreciated by myself, I have designated *trachelismus*.

505. Let us enumerate the nerves principally supplying these muscles: The *recurrent* supplies the constrictors of the larynx; a *descendens septimi* or *facialis* supplies the platysma-myoides; the *accessory*, the cleido-mastoid and the trapezius; the *descendens noni*, the omo-hyoid!

506. Can all this be accident? or is there a principle involved in it hitherto undetected?

§ VI.—*The Ganglionic System.*

507. If we be exposed to a partial current of air, in the neck for example, or to wet feet, an inflammatory attack is the frequent result. This may affect the pleura, the peritonæum, &c. It is an effect produced through the ganglionic system.

508. If there be pleuritis, or peritonitis, the patient, being placed in the perfectly upright position and bled to syncope, loses a large quantity of blood before the signs of incipient syncope are perceived. There are general tone and *tolerance* of loss of blood.

509. If, on the other hand, there be any of those maladies which consist in *irritation* as a cause, and various nervous ailments as the effect, there is very slight tolerance of loss of blood.

510. These phenomena belong, I imagine, to the ganglionic system.

511. In acidity in the stomach, the pulse is frequently irregular and intermittent.

512. In the case of tuberculous disease in the abdomen, there is a frequent, small pulse, with coldness of the ears, nose, hands, and feet.

513. In the case of *perforation* or *rupture* of an organ, as of the stomach, or intestine, of the gall-bladder, or urinary bladder, or of the pleura or peritonæum, in general, the symptoms of *collapse* or of *sinking*, coldness and clamminess of the surface, sunken features, and feebleness and threadiness, with frequency, of the pulse, speedily supervene.

514. These and other phenomena of the same *Class* are produced through the medium of the ganglionic system.

515. The crush of a limb by an accident produces similar effects, through the same medium. It is pure *shock*.

516. It is a remarkable fact, that, in the web, and in the general cutaneous and muscular tissues, &c. of the frog, a minute nerve is always the near associate of a minute artery. Dr. Robert Lee has observed the same fact in the heart, the uterus, &c. in the human subject. Is this strict association of artery and nerve the *type* of the circulating, secretory, and nutrient organs?

517. In the state of *sinking* of the vital powers, the balance of secretion and absorption in the lungs is broken, and there is a small crepitous rattle first, and the tracheal or 'dying' rattle in the second place, frequently with little cough; in the intestines the same balance is impaired, and there is tympanitis;—affections of the ganglionic system (?).

518. It is obvious, from the facts which I have here detailed, in this and the former section, how much the subject still requires investigation.

FINIS.

EXPLANATION OF THE FIGURES.

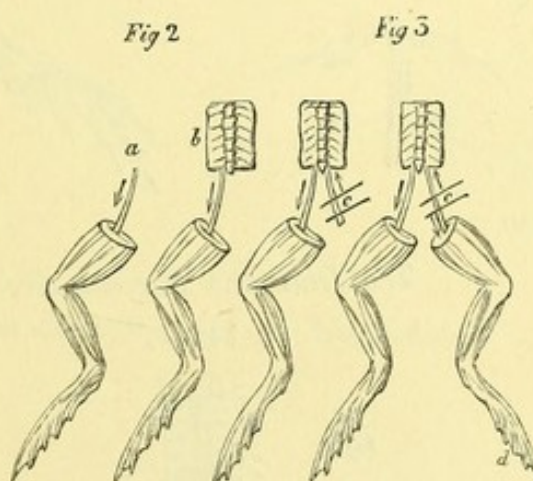
These *Figures* are reduced from Diagrams used in the Lectures. They have no pretension whatever to anatomical accuracy. They are mere sketches, only intended to convey an *Idea*.

DEMONSTRATION

Of the identity of the *vis nervosa* of Haller, *a*, *b*; of the motor principle in the experiments of Redi, Whytt, &c. *d*; of

The Diastaltic Mode of Action of the Vis Nervosa,

c, c;



and of

The Diastaltic Nervous Arc in Anatomy.

§ 36—; 41—; 48—; 159.

Irritation at *a* and *b* induces contraction of the muscles below; irritation at *d* induces diastaltic action in the other limb; irritation by galvanism at *c* induces *both*.

*Analysis
of
The Nervous System.
§ 124—.*

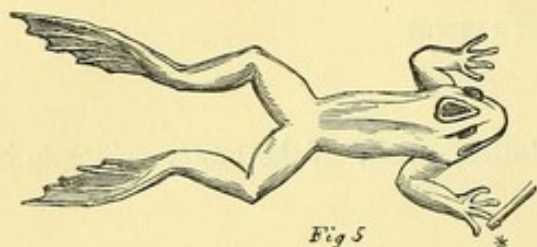


Fig 5



Fig 4



§ 50.

*Analysis
of
The Diastaltic Nervous System.
§ 135—.*

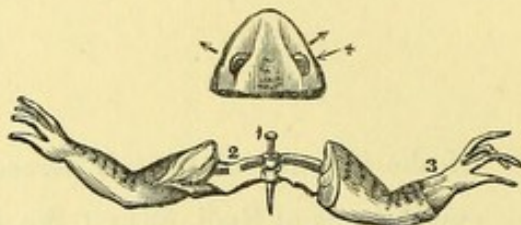
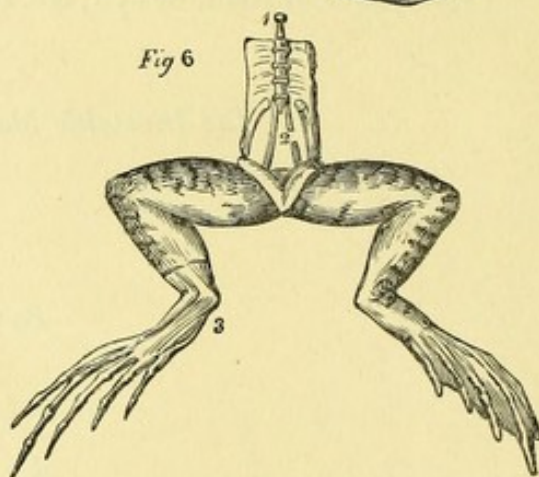
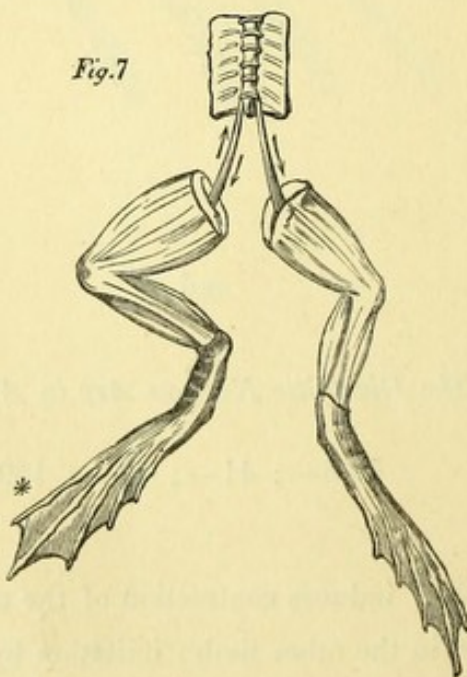


Fig 6



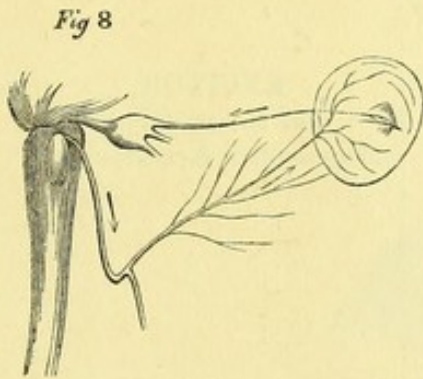
*The Diastaltic Nervous Arc.
§ 142—.*

Fig.7

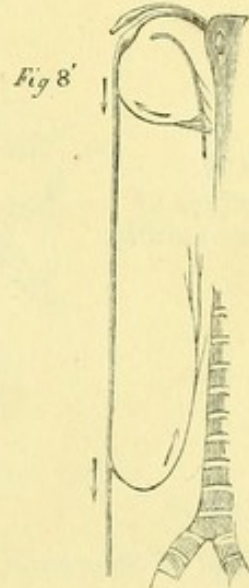


Physiological Diastaltic Arcs.

*Diastaltic Arc
of
The Eye-lid.
§ 170—.*

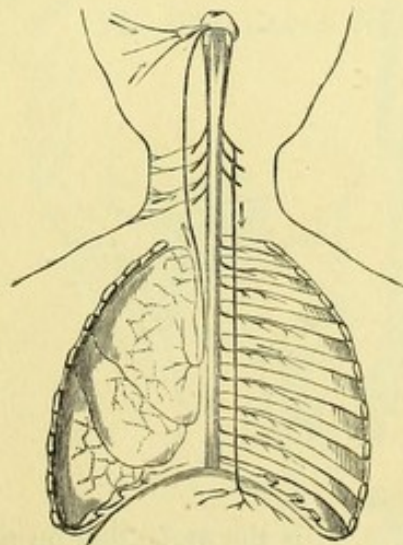


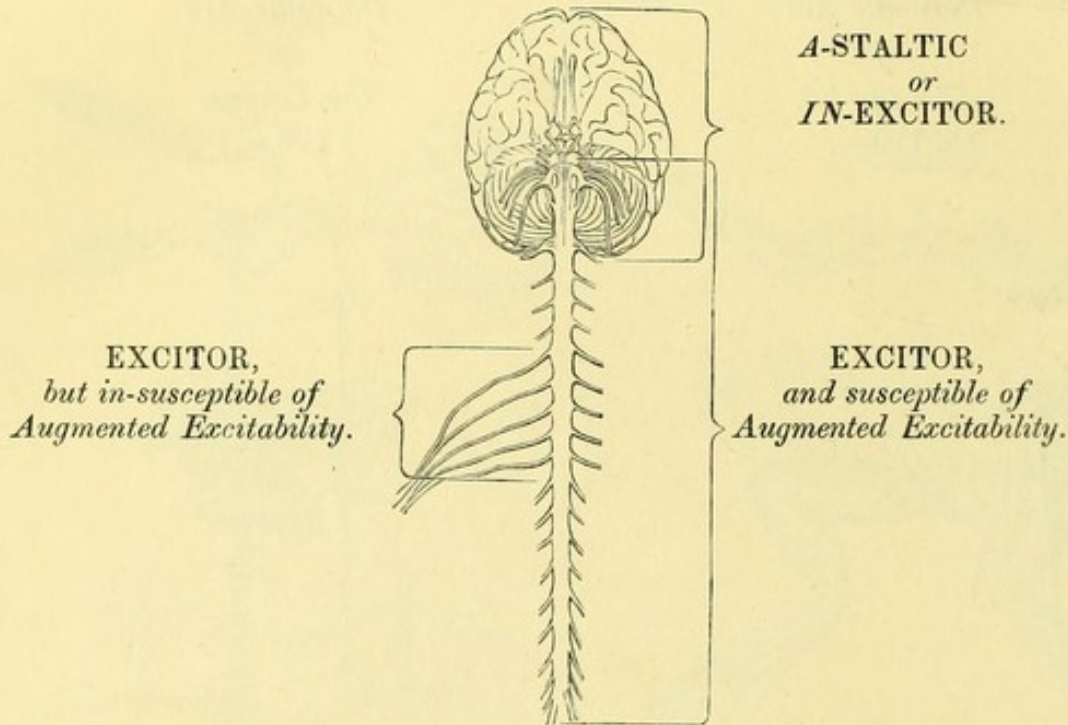
*Diastaltic Arc
of
The Larynx.
§ 172—.*



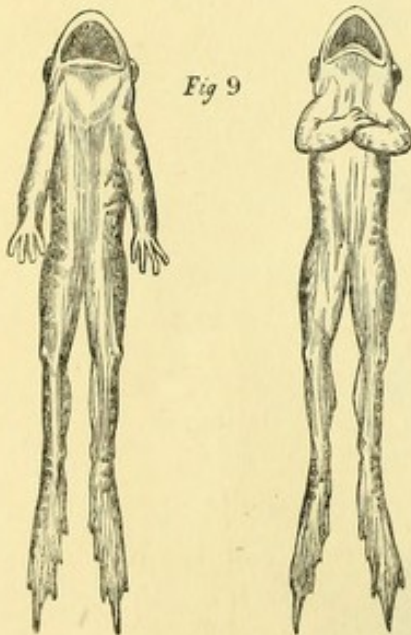
The Diastaltic Arcs of Respiration.

§ 170—.

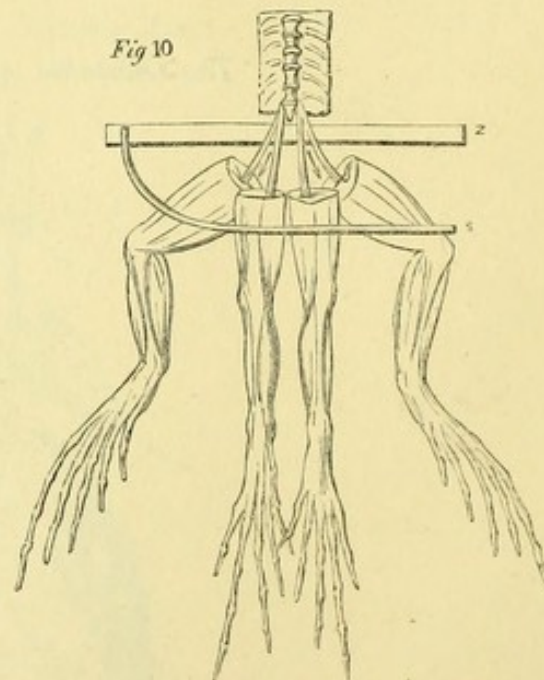


Division of the Nervous System into Astaltic and Staltic.§ 38—; 87—; *Pref.* p. viii.*The Tetanoid Effect of Strychnine.*

§ 134; 428—.

*The Tetanoid Electrogenic State.*

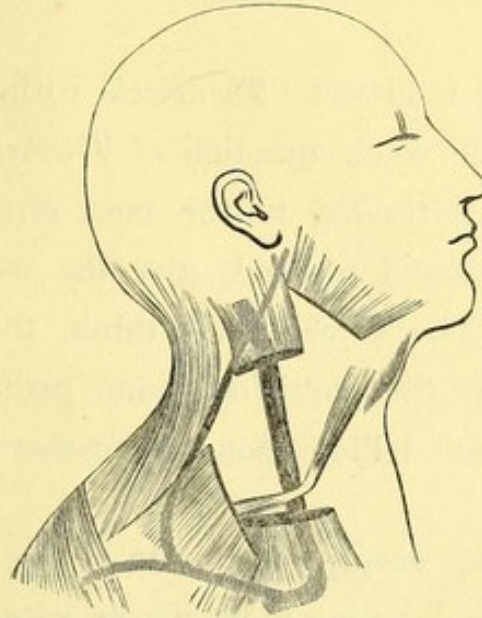
§ 402—; 425.



The figure on the *right*, *Fig. 9*, is the *male*, that on the *left*, the *female*, frog.

It will be observed that the tetanoid state, in *Fig. 10*, is produced by the *direct current*. See § 399; 407.

The Neck as a Medical Region.
§ 503.



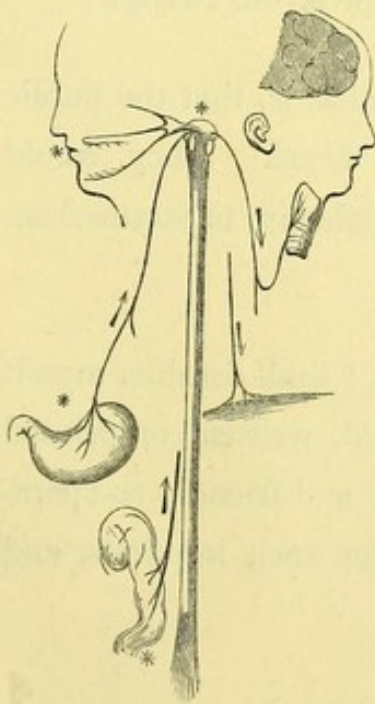
Pathological Diastaltic Arcs.

Laryngismus.

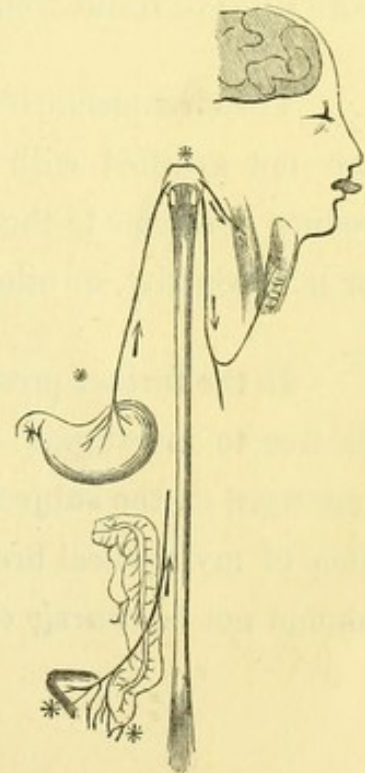
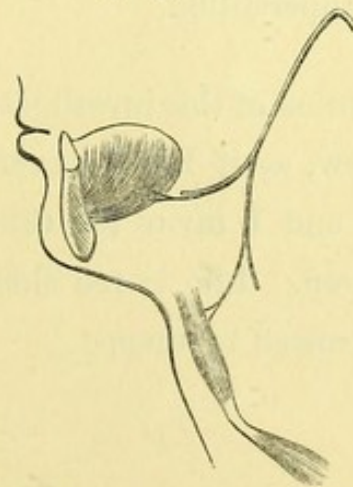
Pref. p. vii, viii ; § 497.

Trachelismus.

§ 504.



The Hypo-glossal Nerve ;



Its distribution to the genio-glossal and to the omo-hyoid, &c. inducing the *bitten tongue* and *compressed jugular*. See § 503—.

POSTSCRIPT.

It is my intention to dissect ‘*The Neck*’ with the most scrupulous care, and to subject the whole question of *Trachelismus* (assuming frequently the form of *torticollis*) to the most scrupulous experimental investigation. At present I can only give the most general results of clinical observation. The subject is, I think, the most extraordinary recently brought before the physiologist and pathologist. It is that of Staltic or Diastaltic action, telling upon the muscles of the neck.

There is something deeply affecting in sitting by a patient afflicted with epileptoid seizures, listening to details, or witnessing phenomena.

The next objects are *Prevention* and *Cure*. Such prevention and cure will not result from *empiricism*. Our only hope is—in *Science*!

The circumstance most to be regretted in practice, is, that the public are not satisfied with pure and unsophisticated *Truth*. They would reduce *Medicine* to the condition of astrology or alchemy, to mesmerism, or homœopathy, or other superstition.

In the further prosecution of this investigation, I shall consider myself as free to investigate anew, as if I had never said, written, or printed one word on the subject; and I invite the candid and friendly co-operation of my medical brethren. Life is too short for such inquiries, and should not be *entirely* engrossed by them.



