

Physiology, or, An attempt to explain the functions and laws of the nervous system : the contraction of muscular fibres, and the constant and involuntary actions of the heart, the stomach, and organs of respiration, by means of simple, universal, and unvarying principles : to which are added, observations on the intellectual operations of the brain : and on the diversity of sensations : with remarks on the effects of poisons : and an explanation of the experiments of Galvani and others, on animal electricity / by E. Peart, M.D. &c.;

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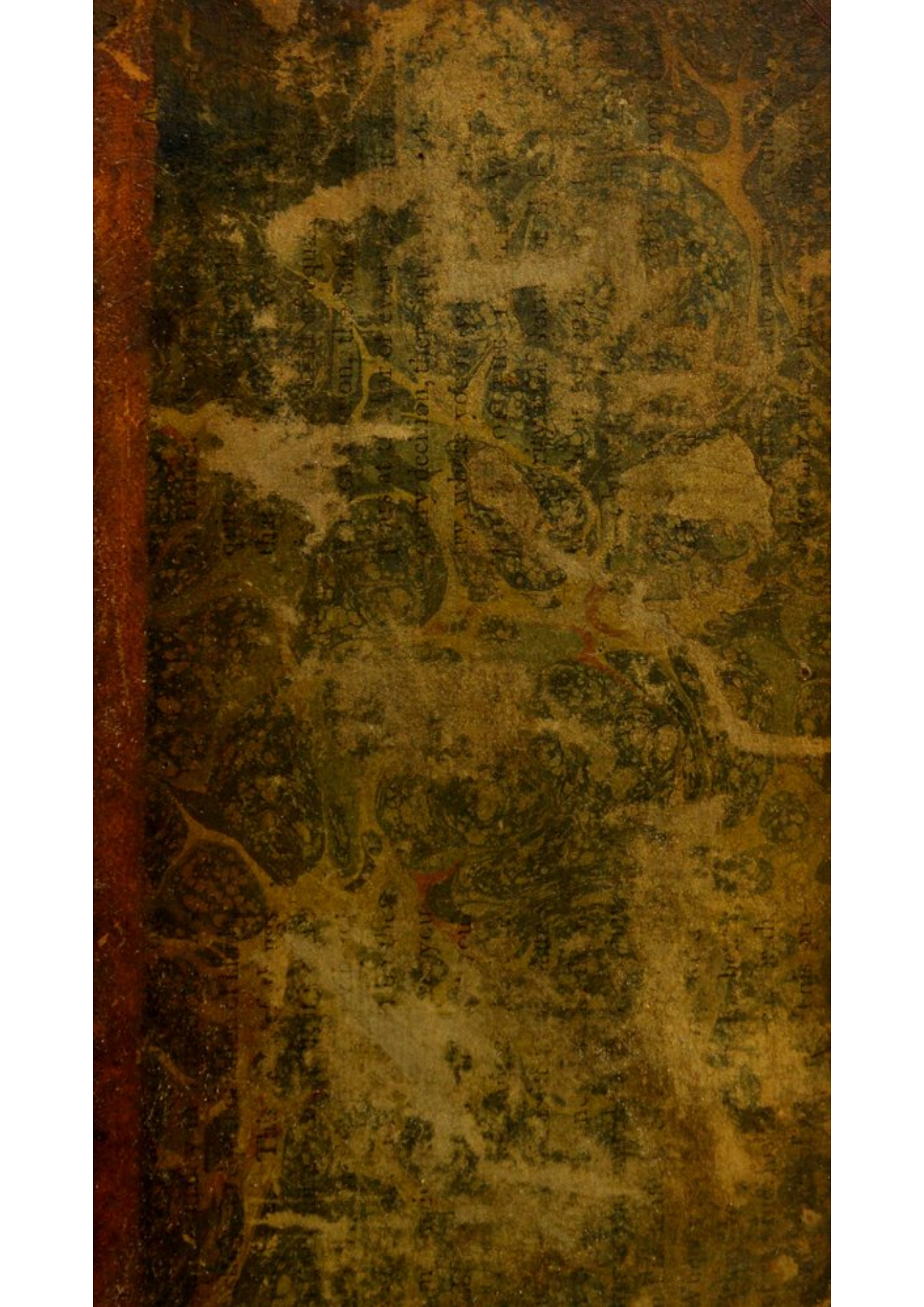
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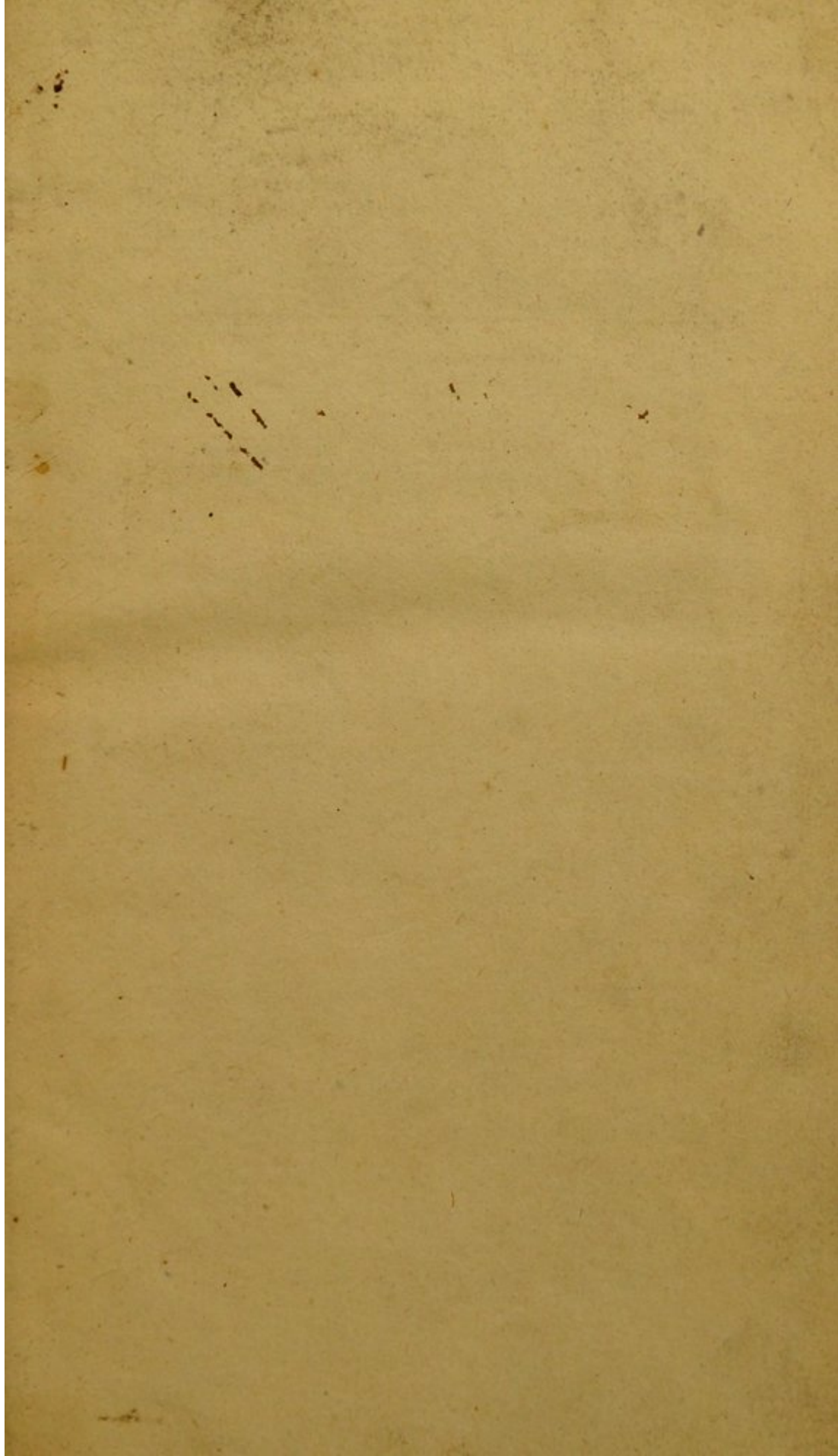


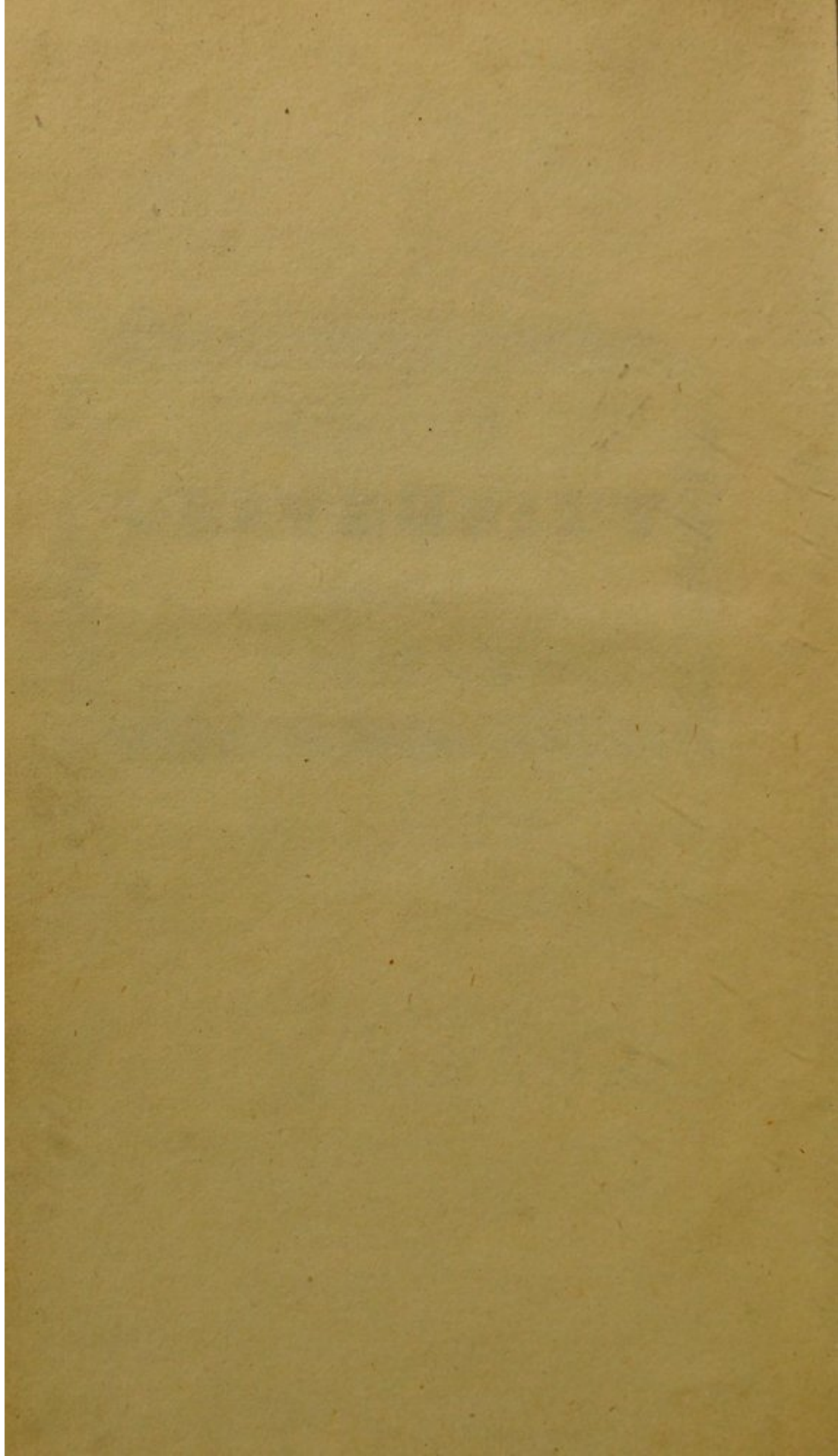
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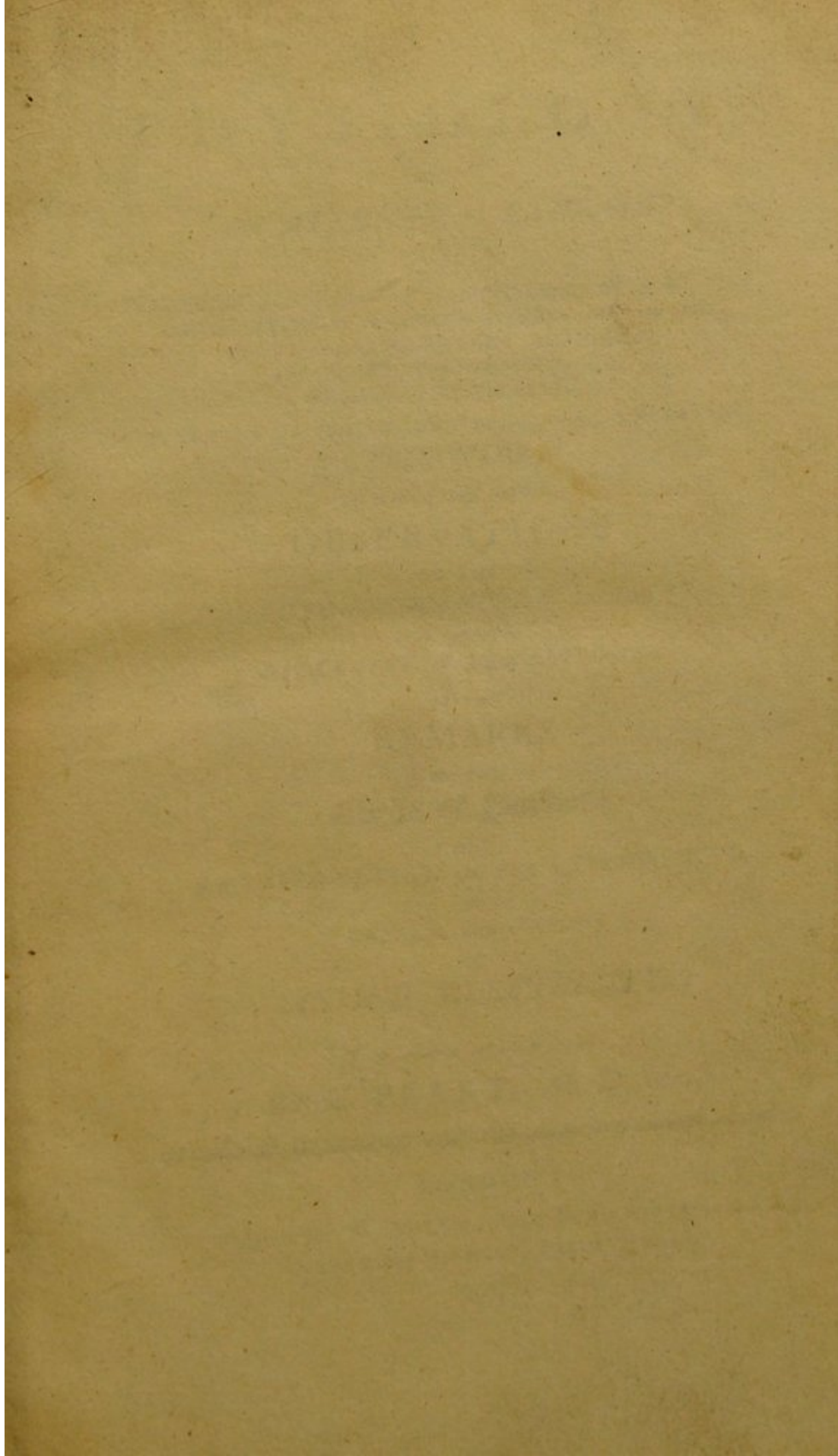
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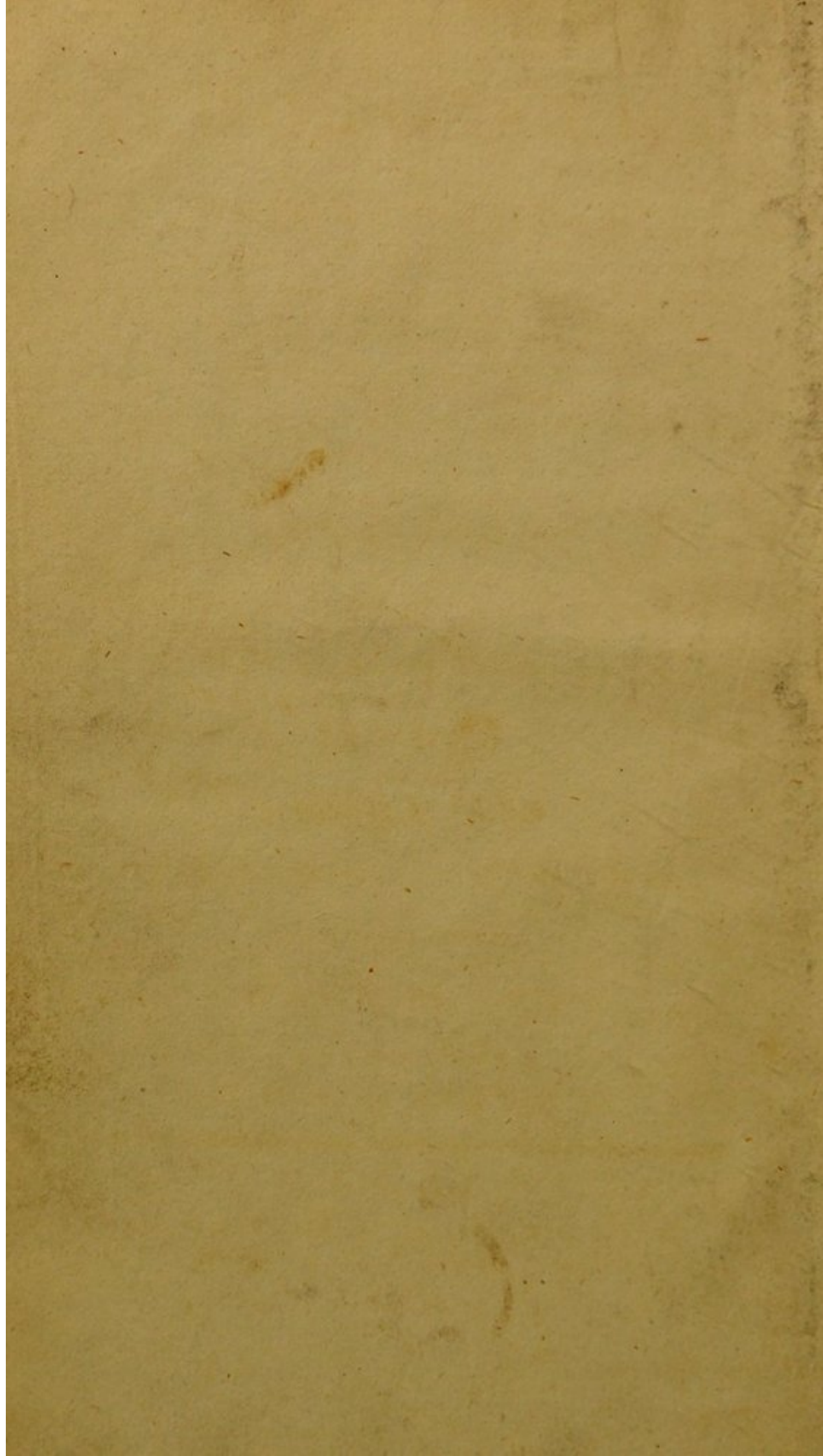
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PHYSIOLOGY;

OR,

An ATTEMPT to EXPLAIN

THE

FUNCTIONS AND LAWS OF THE NERVOUS SYSTEM; THE
CONTRACTION OF MUSCULAR FIBRES; AND THE CON-
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THE HEART, THE STOMACH, AND
ORGANS OF RESPIRATION,

BY MEANS OF SIMPLE, UNIVERSAL, AND UNVARYING
PRINCIPLES.

TO WHICH ARE ADDED,

OBSERVATIONS

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AND ON THE

DIVERSITY of SENSATIONS:

WITH

REMARKS

ON THE

Effects of Poisons;

AND

AN EXPLANATION OF THE EXPERIMENTS

OF

GALVANI AND OTHERS,

ON

ANIMAL ELECTRICITY.

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By E. PEART, M. D. &c.

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1798.



# PHYSIOLOGY

OF THE HUMAN BODY

BY J. H. MASON, M.D.

OF THE UNIVERSITY OF CHICAGO

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## P R E F A C E.

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WITHIN the last eight or nine years I have frequently offered my sentiments to the public on various philosophical subjects. I have rejected the commonly received opinions on the general principles and operations of nature, because they are *absurd*; but I have never rejected them without first of all proving that they are so. I have proposed the principles upon which I have founded my own theory, but not without proving, as far as the nature of the subject will admit, that those principles do actually exist; and the laws by which they are regulated are deduced from facts which nature every moment presents to our view.



That the chemical doctrines of M. Lavoisier, and the electrical theory of Dr. Franklin, are founded on *absurd principles*, and are, therefore, *erroneous*, I have *proved* by such arguments as I do not for a moment hesitate to assert, are absolutely conclusive : whatever, therefore, may be the fate of my own theory, *theirs*, to a certainty, *are false*. With respect to my own *principles*, I feel as confident of their existence as of my own ; how far I have succeeded in developing the *laws* by which they are governed is another matter ;—many of my conjectures may be erroneous, and much remains to be discovered. Confidence, however, may be misplaced ; and I have all along declared, and still declare, that I would not for a moment hesitate to *abandon* both my *theory* and *principles* were they once proved to be *fallacious*.

That the theories of Dr. Franklin and M. Lavoisier are *generally adopted* is granted ; but, that is *no proof* that they are either *true* or *rational*.

Reason never was, nor now is necessary, to



establish an opinion ; witness the number of doctrines which have been advanced, embraced, and forgotten ! neither is the general assent of a million any proof of veracity, for no opinion is *too absurd* to want converts, as is evident in *philosophy* as well as *religion*.

When I read in a modern publication of celebrity, that venous blood attracts oxygen from the azote of atmospheric air, and in the next paragraph that azote attracts oxygen from blood, without any reason why or wherefore, can I call it philosophy ? Surely not—the assertions manifestly contradict each other, and the theory which rests upon such principles and explanations, appears to me rather *contemptible* than satisfactory.

When I am told that the brain secretes the *electric fluid*, and that the transmission of a portion of the electricity to any particular nervous fibre, causes the muscle to which it is distributed, to act—what am I to understand ?—The same philosopher as being of the Franklinian school,



allows that the brain cannot communicate its positive electricity to a muscle, unless *that muscle* be *negative* : the will, then, instead of transmitting electricity from the brain, must act upon the *muscle* by rendering it *negative*, and then the electric fluid of the brain rushes to the muscle to restore the equilibrium :—but, when the muscle was *not* in action, it had its usual proportion of electric power ; how did the will, then, dispose of that natural electric power when it rendered the muscle negative ?—in short, the opinion is preposterous !—The powers of the brain and nerves *cannot* be in an *electric state* ; for it is an undoubted fact that the nerves are conductors of electricity, and that the electric fluid communicated to *any part* of the common trunk of a nerve, will affect *every fibre*, and will excite *every* terminating branch of that nerve ;—but the *voluntary* act of the mind can transmit its power to *one single muscle alone*, though the nerves connected with ten thousand other muscular fibres were collected into the same bundle so as together to constitute one nerve.



When I am assured that the blood by circulating through the arteries to a muscle, returns by the veins, loaded with powdered charcoal, can I avoid asking how and where it acquired its charcoal?—And when I am told that the charcoal thus mixed with the venous blood, combines with oxygen gas in the lungs, and forms fixed air,—can I avoid being struck with the singularity, that simple charcoal can combine with oxygen gas *in* the lungs, at the temperature of 96°, when charcoal *out* of the lungs might be exposed to the same air to eternity, without producing fixed air, unless a *much greater* degree of heat were employed!—the charcoal *in* the lungs, then, *cannot* be in the *same state* as the charcoal *out* of the lungs; and some principle or cause is overlooked, which renders the antiphlogistic doctrine lame, imperfect, and unsatisfactory.

When I am gravely informed, that the air which almost instantly congeals the blood of the hardy Siberian himself, is formed of 999 parts out of the 1000 of pure, genuine, elementary *Fine*, can I tell which the most to admire,—the



*absurd fancy* of the first conceiver of such an idea, or the *wonderful credulity* of the multitudes, who swallow the absurdity as they do the gospel!—

When I read, in every periodical work, from the Transactions of the Royal Society, down to the humble Review, that the proud *diamond* itself is nothing more than *crystallized charcoal*,—what can I add—but, that when the readiest and best method of *thus crystallizing charcoal*, is clearly pointed out, I will confess, that the discovery is as *brilliant* as it is now wonderful! wonderful! wonderful!

According to the antiphlogistic system, carbon, azote, and hydrogen, are three distinct principles; but as each of them is capable of *combining* with the *acid* principle and of *saturating* it, more or less completely; and as they are mutually convertible into each other, as is too well known to the antiphlogistians to need insisting upon, I hesitate not to affirm, that they are *one* and the *same principle*, in different states of pu-



rity, with respect to the admixture of other matters, and with different proportions of the *power* by which they are rendered atmospheric; and that principle I distinguish by the name of the *alkaline* or the *antacid* principle; which, therefore, includes both carbon, azote, and hydrogen.—In chemistry, those distinctions are useful; but as my present subject does not require the specification of the *peculiar* states of the antacid principle, the general term *alone* is employed in the following tract.

But to consider all the absurdities and contradictory conclusions of the antiphlogistic doctrine, would be an unnecessary repetition of what I have already more fully accomplished. That it is *puerile* and *unphilosophical*, I assert, without the most *distant* fear of contradiction; and that the Franklinian doctrine of electricity is, if possible, still *more absurd*, I have proved to a demonstration, on former occasions; and have, repeatedly, called upon its admirers to defend it—but in vain.



As the subject of this tract is chiefly physiological, I cannot refuse myself the gratification of acknowledging how much I feel myself indebted to my first, great, teacher, the justly celebrated Dr. Monro, professor of anatomy at Edinburgh. The extent of his knowledge, the solidity of his judgment, and the penetration of his discernment, impressed my mind with that *profound respect* which I shall retain while I have recollection.

Neither can I forget, nor recollect without cheerfully confessing the many obligations that I think myself under to Mr. Cruikshank. His lectures were replete with information, his wish to instruct was equal to his well-known abilities as a teacher, and his liberality in collecting information from every source, was not less conspicuous than his readiness to communicate it.

For the late celebrated Dr. Hunter my esteem is sincere and unabated ; his pleasing manner, so much his own, of rendering his subject intelligible to every capacity, could not fail of afford-



ing *me* many advantages which I am proud to acknowledge.

There are some few philosophical characters, for whom, though unknown, I have that respect which is so justly their due; and to whom I shall take the liberty of presenting this little tract, as a testimony of that esteem which I feel for men of *science* and *liberality*, howsoever they may differ from me in opinion: the perusal may afford them an hour's amusement, and, although I expect *no converts*, something may, perhaps, occur, which may excite their attention, and lead to future improvements.

Upon a subject like this, much must be left to conjecture; and plausibility must stand in the place of demonstration; it being, perhaps, as impossible to demonstrate, by dissection, the various structure, connexions, and exact organization of the brain, as it is by the powers of optical science, to detect the intellectual powers themselves, in the act of thinking.



Strongly convinced as I am of the value of experiments, I still am equally convinced, that diligent attention and accurate reasoning are equally necessary, without which, experiments are labour in vain.

As no simple experiment can show why the heart constantly beats—how the eye sees—or the brain perceives and reasons—I have ventured to collect what facts have come to my knowledge, and from those facts I have endeavoured, by reason and analogy, to investigate the rest, as far as the limited powers of my mind have been able, *directly*, and *extemporaneously* to proceed.

I have in no case, that I know of, made unfair statements, or drawn unwarrantable conclusions; neither have I proposed one new principle, idea, or explanation, without giving the reason why, nor without being led to do so, by such previous arguments and reasons, as appeared to me satisfactory at the time.

I by no means, however, offer this as a finished



work upon the subject; the result of *twenty years* mature deliberation:—on the contrary, I declare, candidly, that it was *begun* upon, merely as a winter-evening's amusement, and *finished* in *less* than *twice* that number of *evenings*.

I pretend to no order, or method, but what spontaneously arose in the prosecution of my subject; nor to any elegance of language, or choice of terms,—those expressions *only* being employed which arose simultaneously with the ideas.

In fact, I honestly confess that I think and write merely for my amusement—and as I have *no* expectations of making converts to my peculiar opinions, I by no means feel disposed to convert amusement into *labour*, by the drudgery of *correcting* and *transcribing*.

As, however, many of the ideas in this tract are *new*, I present them undigested and extemporaneous as they are, to those few who have *capability* to understand, and *liberality* to consider them impartially. If they have inclination to attend to



the subject, my wish *is*, that they may meet with something worthy of *their* attention ;—something which may tend to the improvement of science ;—something which may render their labour not in vain.

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# PHYSIOLOGY.

## SECTION I.

*A general view of the system of the human body.*

1. **T**HE human body is formed of solids <sup>1. compo</sup> and fluids, of different degrees of <sup>of the b</sup> firmness and consistency; and of different properties; as being composed of different principles in various proportions, and modes of combination and arrangement.

2. The more solid parts are the bones; these <sup>2. bone</sup> give form and strength, and constitute the basis to which the softer parts are attached; and



by which, parts of the greatest importance are defended.

*branches.* 3. The matter generally employed in forming and connecting the parts together, is simply fibrous or membranous; of this the vessels, necessary in the system, are in a great measure composed; and by it parts of different kinds are connected together, in variety of combinations.

*parts* 4. The actions or peculiar functions of the system, however, chiefly depend upon the brain and nerves; the heart and blood-vessels; and the moving, or muscular fibres.

*and Nerves* 5. The brain and nerves constitute the most refined and wonderful part of the general system. They are connected together; or, perhaps, the nerves are, in general, merely productions, or elongations of the brain, from which they proceed, as from a common centre; for the purpose of conveying the energetic influence of the brain to distant parts; where that



influence is necessary to produce the functions of the parts to which they are distributed, or for the purpose of communicating impressions made on the nervous extremities to the brain.

6. The heart and blood-veffels are the next *6. Heart* important part of the system. The heart is the centre from which the blood-veffels proceed, or to which they tend;—and the arteries are so contrived, as to transmit the blood to the most distant parts, where its influence is required to assist in the peculiar functions of those parts; while the veins convey it back to the heart, after its influence has been imparted.

7. The muscular fibres are equally necessary *7. Muscles* in the system as the former; for they, alone, possess the power of motion, or contraction; and, consequently, without them an universal inertia would prevail, and the body would be an immoveable, inactive mass.

8. The brain and nerves are the only sentient *8. Sensitive* parts of the system. Impressions made upon



the nerves, when sufficiently powerful to excite the attention of the intellectual powers of the brain, constitute sensations; the affection of the nerve being communicated to the brain, if nothing obstructs its course.

*connected  
muscular*

9. The nerves are an essential part in the construction of the muscular, or contracting fibres of the body; for without their presence and agency, muscular fibres are inactive.

*connected  
muscular  
m.*

10. The heart itself is a muscle; and the extremities of the blood-vessels are also muscular. The heart contains a number of blood-vessels in its structure; and the muscular activity of a part, or of the whole system, greatly depends upon the presence of blood; therefore, the blood is requisite to muscular action; and, consequently, the blood-vessels are an essential part in the composition of muscular fibres.

*ion from  
with respect  
action*

11. Muscular fibres, therefore, require both nerves and blood-vessels in their construction.



12. But, a muscle, though formed of nerves and blood-vessels, cannot act without the presence of blood; neither will the voluntary muscles act, although blood be circulating through them, without the influence of the nerves:—consequently, a muscular fibre has both nerves and blood-vessels in its structure; and its action depends upon the flow of blood by these vessels, and of the nervous influence by the nerves; by the conjoint influence of which blood and nervous energy, the muscular fibre is made to contract. *12. Will it act*

From these considerations then we may conclude— *General Conclusion*

1st. That the brain and nerves, and the heart and blood-vessels are the chief sources, of all the powers, by which the different functions of the system are produced. *1. Chief influence of Brain*

2d. That the nerves and blood-vessels are essential parts in the construction of muscular fibres. *2. The influence of Muscular fibres*



*in up  
or fibres*

3d. That the energetic powers of the nerves, co-operating with the blood of the sanguiferous vessels, cause the muscular fibres to contract; and,

*muscular  
tion of  
t.*

4th. That all the actions of the body are produced, conjointly by the nervous and sanguiferous systems, imparting the influence or fluids they convey to the muscular fibres, into whose composition they enter.

## SECTION II.

*On the brain and nerves ; and on the heart and sanguiferous vessels, with the blood which they convey.*

1. **T**HE brain is composed of the cerebrum and cerebellum. They are distinct portions ; differently constructed and situated ; but wonderfully and intimately connected together.

2. The cerebrum and cerebellum, conjointly, form the medulla oblongata ; the medulla spinalis, and every nerve in the body ; so far as it is possible to be ascertained.

3. It is reasonable then to conclude, that the nerves of the cerebrum are essentially different in their nature, or general properties, from those of the cerebellum ; consequently, that the influence, of whatever kind, or nature it may be,



which is conveyed by the nerves of the cerebrum, is essentially different from that transmitted by the nerves of the cerebellum; for, if the nerves of both cerebrum and cerebellum were of the same nature, and conveyed an influence exactly similar in its powers and properties, there could be no reason given why they are thus derived from distinct origins, and so carefully distributed to every part from each origin.

4. The sanguiferous system is peculiarly destined to convey the blood; which is as necessary in the operations of the system as the influence of the nerves is.

5. The blood is not an homogeneous fluid; it must be formed of those things which are necessary, essentially necessary, to support life; and those essential requisites, are directly the reverse of each other, in their general properties.

6. One thing indispensably necessary to the support of life, is air; atmospheric air; or rather the pure air in the atmosphere. The other es-



essential requisite is food—if either, or both of these be wanting, the functions of the system cease, and death ensues : if air be withheld, life is very soon destroyed ; if food be denied, death is equally certain as the consequence, but at a more protracted period.

7. Air without food, cannot long support the vital powers ; neither can food without air : consequently, they are essentially different from each other in their properties and nature.

8. What then is the leading property of the air, so necessary to support life ? There are different kinds of air ; but it is the pure, vital, dephlogisticated or oxygen gas, or air, alone which is required ; because those kinds of air which contain it in the greatest purity and proportion, are the most salutary ; and those species of air, which do not contain it, are destructive, or at least cannot support life.

9. It is then oxygen, or the acid, or acidifying principle, in the state of air, which is one



essential requisite; without which life cannot be supported.

10. What is the other principle, which must be of a different nature, (5.) which is equally necessary to support the life of an animal? It is obtained from food of different kinds; chiefly vegetable, animal, or produced from one or both of them; and its specific properties may be the best ascertained, by considering what it is which affords the most speedy and evident support to the powers of life, when taken into the stomach.

11. We know then that wine and spirituous liquors produce the most sudden and invigorating effects upon the stomach. Spirituous liquors evidently contain an antacid or alkalescent principle; because, if ardent spirits or alcohol, which is the most pure and potent, be exposed to the action of pure air, or oxygen gas, and accended; the air will lose its aeriform state; the alcohol its spirituous qualities; and water will be the result of their combination:—but we know that pure air, or oxygen gas, is formed



of the acidifying principle; we know that, in many cases, when it is deprived of its aeriform state, it constitutes an acid; therefore, as it is deprived of its aeriform state by combustion with alcohol, and with it forms a fluid which has no acidity; it is evident, that the basis of the alcohol saturates the oxygen, or acidifying principle of the air; and must therefore be of an antacid or alkalescent nature.

12. Alcohol and vitriolic ether afford immediate support or excitement to the system when taken into the stomach; and they are little different from inflammable air, or hydrogen gas; as is very evident from their being easily converted into inflammable air; and from their forming water when accended with pure air or oxygen gas, as inflammable air itself does.

13. It is evident then that ether and alcohol are of the same nature; composed of the same principles; and nearly in the same proportions as inflammable air: and the chief difference is, that inflammable air is the most disengaged, and



in an aeriform state ; while the same principles in alcohol and ether, are combined with some other principle, which detains them in a more condensed state ; or, otherwise, they only differ in the proportion of that fluid which renders the alkalescent, or antacid principle, aeriform.

14. What is the principle which renders oxygen or the acidifying principle aeriform ? and what the principle which renders the antacid, or alkalescent principle aeriform, so as to constitute inflammable air ? Is it fire or caloric ? or is it any one principle common to both pure and inflammable air ; which, by acting upon the acidifying and alkalescent principles, combines with them, so as to render them aeriform ? No, it cannot be one principle ;—because, when a few grains of oxygen, or of the acidifying principle, are converted into air ; those particles are removed far from each other, so as to expand into a fluid occupying a much greater space than before ; consequently, each particle of oxygen must be surrounded with an atmosphere ; and as those atmospheres prevent the particles of oxygen from approaching near to each other, they



must repel, or resist each other, and cannot have any attraction for each other, so as to enable them to combine.

In like manner when the alkalescent principle is converted into inflammable air, each alkalescent particle must be surrounded by an atmosphere, which resists the approach of every other similar atmosphere; therefore, the atmospheres rendering the antacid or alkalescent particles aeriform, being similar, have no attraction to each other, by which they can combine. But, if the pure air, or oxygen gas be mixed with hydrogen gas, or inflammable air, they may readily be made to attract each other and combine; leaving the acidifying and alkalescent particles united together, in a state of perfect neutrality, constituting water.

15. It is evident then, that there are two distinct principles, or powers; one of which will convert oxygen, or the acidifying principle, into pure air; and the other will convert the antacid, or alkalescent principle, into inflammable air: that the atmospheres surrounding the



particles of oxygen, have no attraction for each other ; that the atmospheres surrounding the alkalescent particles, have no attraction for each other ; but, that the atmospheres surrounding the acidifying principle, attract, and will combine, with the atmospheres which render the particles of the alkalescent principle aeriform : in consequence of which combination, the acid and alkaline particles are left, without those atmospheres, combined together, so as to constitute water ; and, from the quantity of fire and light, which is produced during the combination, there can be no reason to doubt, that those two atmospheres, by combining together, and quitting their aeriform states, constitute the fire, and excite the light, which appear at the instant of their combination.

16. It appears, then, that the alkalescent, or antacid principle, is an essential requisite to support the functions of the living body ; that those substances which contain it in the purest and most abundant state, are the most powerful in supporting the immediate operations of the system ; and that all substances, whether animal or



vegetable, which are capable of supporting life, contain this principle in some state and proportion or other.

17. But, it is not the acidifying principle, or oxygen, simply, alone, which is requisite; nor the pure alkalescent principle; nor the two together, which can support the system: on the contrary, the acid principle must be in the aeriform state, by means of its peculiar power in an atmospheric state surrounding its particles; and the alkaline principle must be attended with its peculiar power, which renders it aeriform, though not uncombined, or so abundant as to render its particles in an aeriform state: consequently, the functions of the system require for their support the acid principle rendered aeriform by its peculiar power; and the alkaline principle, combined with certain proportions of that peculiar power, which, in a larger proportion, or in a state of freedom, would convert it into inflammable air.

I have so repeatedly investigated this subject, and come to the same conclusions, in whatever



manner or direction the investigation has been pursued, that I feel the greatest confidence in the veracity of these principles : and, as, upon former occasions, I have found it necessary to apply distinct appellations to the principles in question, for the purpose of more ready and distinct discrimination ; so I shall, here, observe the same method.

Oxygen, or the acidifying principle, then, I shall call, for conveniency, the acid principle.

Hydrogen, or the alkalescent principle, I shall distinguish by calling it the antacid, or the alkaline principle ; which, also, by partial combinations with the other principle, and the powers in different proportions, forms the different kinds of earths.

That peculiar power, or fluid, or principle, which renders the particles of the acid principle aeriform, by becoming atmospheric around them, I shall distinguish by the title of æther, or the æthereal power ; and, the fluid, power, or principle, which,



in an atmospheric state around the particles of the alkaline principle, renders them aeriform; I shall call phlogiston, or the phlogistic power.

From the preceding considerations, then, I draw the following general conclusions :

1st. That the brain consists of two distinct substances; of different powers, and properties : the cerebrum, and cerebellum.

2d. That they are intimately connected together, and invariably accompany each other, in all their ramifications.

3d. That every common nerve is connected with the cerebrum and cerebellum; and, therefore, that every nerve is composed, in fact, of a branch from the cerebrum, and another from the cerebellum.

4th. That every branch of nerve connected with the cerebrum, contains and conveys a peculiar energy, fluid, or power; that every branch



from the cerebellum contains and conveys a peculiar fluid, or power, also ; but, essentially different in its properties from the former ; and, consequently, that every common nerve is composed of a nervous branch from the cerebrum, and another from the cerebellum ; each of which is supplied with its peculiar power, essentially different from the other.

5th. That the heart and sanguiferous vessels contain and convey the blood ; which is composed of two distinct principles, with their respective powers in chemical combination.

6th. That the blood derives its principles and support, from the atmospheric air, constantly taken into the lungs ; and from the food repeatedly taken into the stomach.

7th. That the principle taken from the air is the acid principle, rendered aeriform by the æthereal power.

8th. That the principle selected and acquired



from the food is the alkaline, or antacid principle ; combined with a portion of the phlogistic power.

9th. That the blood, thus constantly supplied with the acid principle, with its æthereal power ; and with the alkaline principle, with its phlogistic power ; is capable, by co-operation with the nerves and their respective powers, of producing all the functions of life ; all the actions and operations of the human system.



## SECTION III.

*On the powers of the brain and nerves ; by which they produce their effects upon muscular fibres.*

1. **I**T has been concluded on probable grounds, (sect. ii. 2. 3.) that the cerebrum and cerebellum, and their respective nerves, are essentially different from each other, with respect to their general properties ; and the fluids, energies, or powers which they contain and convey, when excited to action.

2. What are those fluids, or powers ; and from whence are they derived ? Certainly from the blood ; and the blood acquires them from the air and food, which are so necessary to support the life and animation of the brain.

3. If a man be deprived of a considerable



quantity of blood, he faints ; if the loss be very great, he dies.

If a man be prevented from breathing pure air, the functions of the brain quickly languish ; the senses and reasoning powers are suspended ; and perfect insensibility and unconsciousness usher in death.

If he be deprived of food, all the powers of the body and mind gradually diminish ; and a total cessation of all the functions of the system, or death, is the consequence.

Air of the purest kind without food, cannot preserve the powers of the brain ; and the most generous food and exhilarating cordials are applied in vain, to support and excite the faculties of the brain, if air be wanting.

4. It is evident, then, that the functions of the brain and nerves immediately depend upon the blood ; because if the brain be not largely



supplied with blood, its powers and functions are diminished, or entirely cease.

It is equally certain, that the blood with which the brain is supplied, must contain both the principles which it acquires from the air and from food; for if the blood be deprived of either, or both of those principles, the functions of the brain are suspended, or destroyed. It is evident, therefore, that the brain does acquire from the blood, either the acid principle with its æthereal power, and the alkaline principle with its phlogistic power; otherwise it separates from the blood the æthereal and phlogistic powers, and leaves the acid and alkaline principles combined in the blood.

5. The brain, then, does separate and acquire from the blood, either the two powers; or the two principles with their powers combined with them; because, without a constant supply of blood its functions cease; and, without a constant supply of air and food, the blood is incapable of supporting those functions.



6. But, the principles which the brain acquires from the blood, are applied to the purpose of supporting the actions of the system:—those principles, then, are transmitted from the brain, along the nerves, to the muscles. If we consider the extreme minuteness, or exility of the nervous fibres, which convey these powers from the brain; and the rapidity of the motion with which those powers are transmitted along the nerves; it will appear highly improbable to suppose that the acid and alkaline principles themselves, are propelled along the nerves; and, it is therefore reasonable to conclude, that the brain does, in reality, separate and acquire from the blood, the æthereal and phlogistic powers only; completely disengaged from their respective acid and alkaline principles; which are, therefore, left combined in the blood.

7. We may then reasonably conclude, that the brain and nerves do separate from the blood the æthereal and phlogistic powers; that those powers, when excited, rapidly flow along the nerves to assist in the necessary actions of the



parts to which they are distributed ; that they are discharged from the nerves when they produce those actions ; that a constant supply of those powers from the blood is necessary to replace the æthereal and phlogistic powers expended in those actions ; and, that a constant supply of air and food is therefore requisite to enable the blood to afford those necessary supplies to the brain and nerves.

8. As the æthereal and phlogistic powers, then, are essentially necessary to support the functions of the brain ; and by being excited to flow along the nerves, produce the various actions of the system ; and, as the brain and the nerves proceeding from it are evidently of two distinct kinds ; the cerebrum and cerebellum ; it is natural to suppose, that the cerebrum and its nervous fibres, particularly, secrete and convey one of those powers ; and the cerebellum and its nerves the other. Two distinct powers, or principles, are evidently requisite to support the functions of the brain ; and, as the cerebrum and cerebellum are distinct portions of the brain,



there can be no reason given why those parts are so distinctly formed, unless it be, that each may secrete its distinct power, or active principle, from the blood : and, as the medulla oblongata and medulla spinalis, from which the nerves proceed, are evidently formed of fibres from both the cerebellum and cerebrum ; it is reasonable to conclude, that every common nerve is composed of fibres from both the cerebrum and cerebellum ; and, that every fibre is supplied with that peculiar power, which is secreted from the blood, by that portion of the brain to which it is immediately connected.

I hold it, therefore, perfectly allowable to draw the following conclusions :

1st. That the brain separates from the blood the æthereal and phlogistic powers ; pure and uncombined with the acid, or alkaline principles.

2d. That the brain evidently consists of two distinct portions, of different organization, and



form ; and, that the cerebrum separates from the blood, one of those powers only ; and the cerebellum the other.

3d. That the nerves connected with, or arising from the cerebrum, contain and convey the same power as the cerebrum separates from the blood ; and that the nerves of the cerebellum, only convey that power, or kind of power, which is peculiarly secreted by the cerebellum.

4th. That all the nerves being derived from the medulla oblongata and spinalis, are formed of distinct fibres, from both the cerebrum and cerebellum ; which mutually compose and constitute the medulla oblongata and medulla spinalis.

5th. That every common nerve thus formed, and consisting of distinct fibres from the cerebrum and cerebellum, does contain both the æthereal and phlogistic powers ; the fibres arising from the cerebrum, distinctly possessing one



power ; while the fibres from the cerebellum distinctly contain the other.

6th. That when these powers are excited, they flow along the common nerve, to the parts whose actions they are concerned in producing ; and are there discharged from the nervous extremities.

7th. That the brain must require a supply of æthereal and phlogistic powers from the blood, equal to the expenditure in producing the actions of the system ; and, consequently, that the necessity of air and food to restore those principles to the blood, must equal the degree of action in the system, by which they are expended.



## SECTION IV.

*On the action or contraction of muscular fibres.*

1. **M**USCULAR fibres, whether they be subject to the will, or act independently of it, are still of the same nature : their contractions are similar in effect ; and, therefore, to be attributed to similar causes.

2. A muscle, subject to the will, or what I shall call, for conveniency, a voluntary muscle, cannot be made to act by volition, if the nerve by which that muscle is connected to the brain, be cut ; consequently, the nerves perform an essential part in voluntary muscles.

3. But, as contraction is an effect produced upon a muscular fibre ; and as the nerves are essentially necessary in producing that effect, in



voluntary muscles; so they must also be essentially necessary to produce that effect in all fibres, whether voluntary, or involuntary.

4. The nerves, then, form an essential part in the construction, and communicate a power, essentially necessary in producing the contraction of all muscular fibres, whether voluntary, or involuntary.

5. If a man, in perfect health and vigour, be suddenly deprived of a large quantity of blood; although the brain and nerves, a moment before, were replete with power and animation; yet, upon that loss of blood, the power of moving the muscles will be lost also.

If in an animal of any kind, in perfect health and vigour, the arteries supplying any muscular part with blood, be cut, or tied; the power of moving that part, or muscle, will be diminished, though the brain and nerves are unaltered and unexhausted. Consequently, the



presence of blood is essentially necessary to the perfect action of muscular fibres.

6. What is contraction?—In what does the contraction of a muscular fibre consist?—The fibre is shortened; its extremities are brought nearer together:—in fact, the particles of matter, of which the muscular fibre is composed, are approximated; that is, they are attracted nearer to each other.

7. Muscular contraction, then, is neither more nor less than this; the particles of matter, arranged so as to form a fibre, by the influence of the nerves, are attracted nearer to each other.

8. The component particles of a muscular fibre, in their common, or inactive state, are considerably distant from each other: the nerves impart a power, or powers, by which those distant particles are attracted to each other; consequently, their distance must be lessened, and the fibre they form must become shorter.



9. But, as the particles composing muscular fibres when not in action, are distant from each other; the power by which they are rendered attractive to each other must be extended from one particle to another; since nothing can act where it is not: consequently, the power communicated by the nerves, must extend around the component particles of the muscle, in an atmospheric state; so, that the atmosphere of one particle may be in contact with the atmosphere of the next particle to it.

10. But, if a power forms itself into an atmosphere around a particle of matter, it is evident, that it does not simply attract that particle so as to enter into close combination with it; but, on the contrary, it merely arranges itself around it, in an atmospheric state; therefore, it cannot be supposed that two similar atmospheres, thus arranged, can attract each other.

11. It is well known, that the particles of the acid principle, when they acquire atmospheres, and become aeriform, are not attrac-



tive amongst themselves; on the contrary, the atmosphere surrounding each acid particle, acts against, or resists the approach of every similar atmosphere: and, as was before observed (sect. ii. 14) the particles of the alkaline principle, when surrounded by the phlogistic power, are kept distinct and distant from each other; consequently, those atmospheres of phlogiston do not attract each other, nor draw the alkaline particles together.

12. But it has been shewn, (sect. ii. 14) that an atmosphere of the æthereal power, surrounding the acid principle, will attract an atmosphere of phlogistic power, around its antacid principle; and by that attraction they will draw their respective particles of acid and alkaline principles into contact; consequently, by analogy we are led to suppose, that muscular fibres are formed of particles of the material principles, simply connected together, by simple fibrils; and, that the nerves of the two kinds, convey the two contrary powers, to those material particles in muscular arrangement, each



power communicating with its alternate particles; which powers, when discharged from their respective nervous fibrillæ, assume an atmospheric state around the muscular particles; and, that those contrary atmospheres of the æthereal and phlogistic powers attract each other, and the particles which they surround, into combination; by which means, the fibres formed by those particles, must be rendered shorter, of course.

I therefore conclude—

1st. That every muscular fibre is formed of particles of the material principles, in muscular arrangement, connected together by simple fibres.

2d. That those particles are alternately connected with the two kinds of nervous fibrillæ; every other particle being connected with the æthereal; and every intermediate particle with the phlogistic nervous fibrillæ, or the fibres which convey those powers.



3d. That when the nerves are excited, they discharge their respective powers.

4th. That those powers flow to, and surround their respective particles of matter, in muscular arrangement; and,

5th. That the æthereal and phlogistic powers, thus surrounding the alternate particles of the material principles in muscular arrangement; by their mutual attraction to each other, draw their respective material particles into contact; and, by that means, the fibre formed by those particles is shortened; and the æthereal and phlogistic powers being discharged, combine together, and constitute fire, or the heat which is produced in animals, by the functions of life.

It is not easy to conceive, however, how the æthereal and phlogistic powers, thus simply communicated to the particles of matter in muscular arrangement, can form atmospheres around those particles, so as to extend from one to the



other; when in their common, or inactive state, they must be considerably distant; because, as the æthereal and phlogistic powers flow along the nerves, they cannot be in the state of atmospheric arrangement.

If, then, the æthereal and phlogistic powers, when excited to flow along their respective nerves, are simply excited, but not atmospheric, it is natural to suppose, that when communicated to their respective particles, in muscular arrangement, they will flow around them in states of simple excitation, but not forming any extensive atmospheres:—but, as those particles in muscular arrangement are distant from each other, some intermediate powers extending from one particle to another, must be necessary, to bring them together, and those powers must be excited by the nervous powers.

It appears, then, that the nervous powers, when excited, excite other powers; and that those powers draw the muscular particles together by their attraction to each other.—But, be-



fore we proceed further, it may not be improper to consider what attraction itself is; in what circumstances it takes place; and what are the powers and conditions necessary to produce it.



## SECTION V.

*On attraction, and the powers by which it is produced.*

1. **A**TTRACTION is the force, or power, drawing two or more bodies towards each other; or holding them together when in contact.

2. Attraction is an effect, produced by an adequate cause: nothing cannot be adequate to the removal of two bodies towards each other; therefore, whenever two distant bodies are attracted towards each other, it must be by an intermediate something; possessing the power of moving them in those directions.

3. Attraction implies, at least, two bodies; but does it require that each substance should



have its attractive power, or is one simple attractive principle sufficient to explain attraction in all cases? for, as attraction is a simple effect, it must have a simple cause; and the same effect, in whatever circumstances it is produced, must be referred to the same cause.

4. Let us then attend to the power or powers by which attraction is produced, in its simplest and most evident state; that is, the power which the magnet possesses of attracting iron.

5. A magnet possesses the power of attracting iron at a considerable distance:—this power is a something in an atmospheric state, which extends from the magnet, as its centre, to the iron; as is evident; because it may be destroyed by fire, and restored again by another magnetic atmosphere, or by the electric fluid.

6. If a needle be rendered magnetic, what is called its north pole will evidently attract iron at the distance of six inches; its con-



rary, or south pole, also, will attract iron at the distance of six inches; consequently, each pole of the needle has an atmosphere of six inches extent from the magnet, and each of those atmospheres attracts iron.

7. If another needle be rendered magnetic to an equal degree; its north, or south pole, will, also, attract iron to the distance of six inches; that being the extent of those atmospheres.

8. The two needles then have four poles; each surrounded with an atmosphere, attractive to iron at the distance of six inches.—Are all these atmospheres the same fluid?—If so, they will all equally attract or repel each other; because, the same cause must have the same effect, when all circumstances are the same.

9. If we take the north poles of the two magnetic needles, and bring them towards each other, they will repel each the other at the distance of twelve inches:—then the atmo-



spheres of the two north poles, being similar, repel each other;—in like manner, and at the same distance, the two atmospheres of the south poles will repel each other.—It is evident then, that magnetic atmospheres, north or south, will attract iron, and repel each other.

10. But—if the north pole of one magnetic needle be brought towards the south pole of the other, they will attract each other, at the distance of twelve inches.—It is evident, from the preceding considerations, that similar atmospheres repel each other:—it is evident, in this case, that the atmospheres of the north and south pole attract each other: consequently, they are not similar atmospheres; nor can they be formed of the same principle, or power.

11. It is evident, then, incontestably so, that there are two distinct powers; that one of them, being excited to arrange itself in an atmospheric state around one extremity of a needle, the other power arranges itself in a similar manner around the opposite end; that either atmo-



sphere will attract iron: that either atmosphere will repel, or resist, the approach of another atmosphere, formed of the same principle, or power; but, that the two contrary principles will powerfully attract each other, and the needles which they surround, into contact, whenever the atmospheres formed by them are brought within each other's influence, or extent.

12. On a former occasion, (sect. ii. 14, &c.) when considering the nature of aeriform fluids, the conclusion was the same:—the atmospheres surrounding particles of the acid principle, and rendering them aeriform, are certainly formed of the same principle or power; and those atmospheres as evidently repel each other. By repulsion, however, in this and every case, I mean no more than the resistance which bodies, fluids, or powers, make against each other, when any external force is applied, tending to make them approach nearer than the point of simple contact.



The atmospheres furrounding particles of the alkaline principle are similar, and repel each other :

But, if an acid and alkaline gas be mixed together, their respective atmospheric powers will instantly attract each other; and drawing the acid and alkaline principles together, will leave them in combination, and disappear.

It is evident, then, in this case, as in magnetism, that similar atmospheres repel each other: that the atmospheres of the acid and alkali attract each other; therefore, they are not similar; and, consequently, it is evident, that particles of the acid principle are rendered aeriform, by means of a power of one kind, arranging itself in an atmospheric state around each particle; that the particles of the alkaline, or antacid principle, are rendered aeriform by a power of another kind; that similar atmospheres, or of the same power, in all cases repel each other; but, that the atmospheres formed by one power, will, in proper circum-



stances, attract and combine with the atmospheres formed by the other ; and by that co-attraction of the two atmospheres, their respective bases of acid and alkali are drawn into combination.

13. That the acid and alkaline particles themselves can have any attractive influence upon each other in the aeriform state, is impossible.

A pint of pure air, formed of the acid principle rendered aeriform, weighs, in the common atmosphere and temperature, about nine grains ; —a pint of nitrous acid itself, weighs about nine thousand grains ; —a particle of the acid principle then, in an aeriform state, occupies a space one thousand times greater than when it is in its acid state.

The power, therefore, which constitutes the atmosphere of a particle of the acid principle, and renders it aeriform, is one thousand times more extensive, than the particle of acid itself



is; and, therefore, nothing can touch or act upon that central particle of acid, without first of all removing, destroying, or passing through this atmosphere, so much more extensive than the space occupied by the particle of acid itself.

When a particle of the contrary, or alkaline principle, is in a similar, or aeriform state, it must be surrounded by an atmosphere of at least equal extent; therefore, a particle of the alkaline principle must be rendered aeriform, by being surrounded by an atmosphere, occupying a space one thousand times greater, than what the particle of alkali itself occupies: consequently, it cannot be possible that the acid and alkaline particles, in the centres of those widely-extended atmospheres, can attract each other; or can be brought into contact, but by the mediation of those very atmospheres themselves, attracting each other, and drawing their respective centres together.

14. The united powers of mechanism can-



not make two atmospheres of the same power combine :—they may be compressed, displaced, or deranged, by extra force ; but the instant that the external force is removed, the powers resume their usual state of arrangement ; and this power of arrangement it is which constitutes elasticity.

15. Let us now attend to electric attraction.—If a globe of glass be connected to an insulated conductor ; if an insulated rubber be also connected to an insulated conductor, and the rubber be made to excite the globe, an electric atmosphere will flow from the globe to its conductor ; and at the same time, an electric atmosphere will flow from the rubber to its conductor also.

If two light bodies, suspended by non-conducting filaments, be brought to the conductor of the globe, each will receive an atmosphere of electric fluid ; and the two atmospheres will repel each other.



If two light bodies, in like manner, be applied to the conductor of the rubber, each will receive an atmosphere, and the atmospheres will repel each other;—similar electric atmospheres, therefore, invariably repel each other.

If one light body, having obtained its electric atmosphere from the globe, be brought near to another, whose electric atmosphere was acquired from the rubber; the two atmospheres will attract each other; will draw the two light bodies together; and will combine and disappear:—these two atmospheres, then, attract each other:—similar atmospheres repel each other;—these, then, are not similar atmospheres:—that is, they are formed of different principles, or powers; and, as was found to be the case with magnetic atmospheres, and aëri-form fluids, atmospheres, formed of the same power, repel each other; but, an atmosphere formed of one power, will attract and combine with an atmosphere formed by the other, or contrary power.



16. I assume, therefore, as an incontestable fact, that there are two distinct powers in nature; which are capable of forming different degrees and modes of connexion with the principles of matter; that when either power is excited by its connexion with matter, it has no attraction to the same power, in a similar state of excitement with other portions of similar matter; but, when the two powers are in similar states of connexion with their respective material principles, and in similar states of excitement, that those two contrary powers will attract each other; and, consequently, that power of mutual attraction will be exerted upon the particles of matter which each is connected with; and will draw, or tend to draw them together.

17. As attraction is, in all cases, the same effect, it must, in all cases, be produced by the same cause: these two distinct powers, then, by connexion with the acid and alkaline principles, become attractive to each other; and by



their mutual co-action it is, that every attraction in nature is performed.

18. I have, on a former occasion, (sect. ii. 17.) given the name of the æthereal power, to that power which is excited to arrangement by the acid principle; and that power which is excited to arrangement by the antacid, or alkaline principle, I have called the phlogistic power; and by these names I shall continue to distinguish them.

19. The æthereal and phlogistic powers, then, by their affinities with matter, and attraction to each other, produce all the attractions, whether chemical, magnetic, or electric; and even the attraction which connects worlds with worlds, and systems of worlds with other systems, so as to form a whole—an universe!—as wonderful as it is extensive!—!—!

These two powers are universally diffused, and present in every part,



They are excited by their respective material principles, and receive different degrees and kinds of excitement, as those material principles happen to be differently circumstanced, and combined with them, and with each other.

They constitute the atmospheres which render particles of the acid, or alkaline principle aeriform; they form the magnetic and electric atmospheres:—similar atmospheres of the same power always repel, or resist each other's approach.

Æthereal and phlogistic atmospheres, in similar states, attract each other, and their respective material principles; and when the æthereal and phlogistic powers combine, in a state of excitement, and become disengaged from matter, they constitute a new compound, which is Fire;—and that fire, acting upon them in their common state of universal diffusion, frequently imparts to them that motion and excitement which we call light.



20. Aerial, magnetic, and electric atmospheres, therefore, are formed of the æthereal and phlogistic powers, when excited to atmospheric arrangement by the acid and antacid principles, in different states and combinations: the universal attraction which connects worlds into systems, and systems into an universe, is effected by the same two powers, equally and universally diffused, as far as creation extends; in which state of universality, worlds are their exciting centres.

Light itself is no other than an impulsive excitement communicated to those two powers, in their state of universal diffusion; and fire is produced, whenever those two powers, excited by connexion with the material principles, combine together, in that excited state, and recover their freedom; by the particles of matter they draw together, attracting each other to combination.

21. That all these kinds of attraction are performed by the same two powers, is abun-



dantly evident, from a thousand circumstances.

The æthereal and phlogistic powers in an aerial state, by combination give light; so do electric atmospheres, and so does fire.

Light, by resistance, forms fire: aerial atmospheres by combination form fire; so do electric atmospheres.

Light, fire, or electric atmospheres, impart to the alkaline principle the phlogistic power; and render its particles aeriform, or inflammable air; and they also convert the particles of the acid principle into pure air, by supplying them with the æthereal power.

Magnetic atmospheres are destructible by fire, or by electric powers; and iron may be rendered magnetic by the phlogistic and æthereal powers in an electric state; and, in all cases, if iron be deprived of its phlogistic power, it is rendered incapable of exciting the



æthereal and phlogistic powers to magnetic arrangement.

22. In short, all atmospheres, whether aerial, magnetic, or electric, with their general properties and laws of action, are inexplicable, by the utmost efforts of ingenuity, if two powers are not admitted, as producing those different atmospheres, by each being excited in a state of separation from the other.—Attraction can only be explained by their co-action, and coincidence; fire by their combination; and light by an impulsive excitement communicated to them in their common state of universal diffusion.

That the same two powers, (the æthereal and phlogistic powers,) assume all these states, and produce all these effects, is evident, from the convertibility of one state into another, mutually and reciprocally; from the resemblance that all atmospheric arrangements have to each other; from the repulsion which takes place in every kind of atmospheric arrangement between



similar atmospheres, whether æthereal or phlogistic; from the attractive force which is always produced when the two contrary powers combine, whatever be their peculiar state of excitement; from the fire which they commonly form by combination; from the excitement which that fire commonly gives to light; and from the facility with which light may be converted into fire.

23. From the preceding considerations I draw the following conclusions :

1st. That an æthereal and a phlogistic power exist, universally.

2d. That the æthereal power is capable of being excited to atmospheric arrangement by the acid principle; and, the phlogistic power by the alkaline principle.

3d. That those principles of matter, in different states of combination and activity, impart



different kinds or degrees of excitement, to the æthereal and phlogistic powers.

4th. That two atmospheres of the same power, in similar states of excitement, constantly and mutually repel each other.

5th. That an atmosphere of the æthereal power, will mutually attract and be attracted by an atmosphere of the phlogistic power, in a similar state of excitement.

6th. That the effect of that mutual attraction is combination ; by which the particles of matter those atmospheres surround are drawn together, if not counteracted by a superior power.

7th. That the æthereal and phlogistic powers by uniting in this state of excitement form fire, when disengaged by the combination of their respective material principles with each other.

8th, That light is a progressive excitement



imparted to the æthereal and phlogistic powers in their common state of general and universal diffusion ;—and

9th. That in that state of general diffusion, they are excited by worlds, and systems of worlds, to bind the whole into one grand universe ; in which their attractive powers are so moderated by distance, as just to counteract the rectilinear tendency of motion ; by which a whole is produced ; in which every part is regular in its motion, and undeviating in its circuitous path !

I have so frequently considered this subject in my former tracts, and in so extensive a manner, that I neither think it necessary, nor feel myself disposed to enlarge upon it in this place. There are, however, some peculiarities attending these two attractive powers, which are too essential to be overlooked ; these are the simultaneous production of similar excitements in the two contrary powers by separation : the power which simple



atmospheres have of exciting secondary or external atmospheres; and, the reciprocal changes which take place between the powers of attraction and arrangement; which will therefore be considered in the following section.



## SECTION

*On the general laws by which the æthereal and phlogistic powers are regulated, in their operations with the material principles, and with each other.*

## LAW I.

*THE excitation of the æthereal and phlogistic powers is simultaneous.*

1. The phlogistic and æthereal powers, as already observed, (sect. v. 19.) are universally extended; and, consequently always present in their common state of general diffusion. In that state they have the simple excitement of general attraction, by which distant masses of matter are connected together; consequently the æthereal and phlogistic powers in that state of general excitement attract each other.



2. Whenever iron becomes *magnetic* it invariably acquires two atmospheres; one at each extremity: the atmosphere at the north pole, or at the south pole, repels every similar atmosphere; but the atmosphere of the north will powerfully attract that of the south pole of another magnet; consequently, as before observed, (sect. v. 10.) the two contrary atmospheres are formed of two distinct powers. But, whenever one atmosphere is excited, the other appears at the same time, invariably.

3. It appears, then, that whenever the two powers in their common state receive an excitement of a more powerful kind, they will assume a new state: but, it appears equally evident, that the new state of excitement consists in separation, as well as excitement; for neither power can assume the state of magnetic excitement, at one extremity of a needle; unless the other power assumes a similar state at the other extremity.

4. It appears probable, then, that the æthe-



real and phlogistic powers, when combined, are inactive with respect to other matters ; that when they are separated they are active, and assume the atmospheric arrangement, and retain that activity till they can again combine ; by which combination they draw the material principles with which they are connected, together ; which constitutes attraction.

5. That this is probable from the consideration of magnetic atmospheres, is evident ; and that it is a general law will appear evident from the following observations :

6. Whenever *electric* appearances are excited by an electric substance and its rubber, it is universally known, that two atmospheres are invariably produced. If the apparatus be properly adapted for the purpose, one atmosphere will flow from the electric to its conductor ; and another, at the same time, will flow to a conductor connected with the rubber. These atmospheres are at all times and in all cases simultaneous.



It has been already said, (sect. v. 15, &c.) that these atmospheres are necessarily formed of two powers ; because, like all other æthereal and phlogistic atmospheres, similar atmospheres repel each other invariably ; but, an atmosphere from the electric, as constantly attracts an atmosphere from the rubber.

7. It is evident, then, that the phenomena of electricity depend upon the æthereal and phlogistic powers being excited and separated from each other ; consequently, each assumes the state of electric arrangement at the same instant ; and they remain in those states of electric atmospheres till they have an opportunity of combining ; to effect which combination they draw their respective centres together, if nothing prevents, and by uniting lose the electric properties they had while in a state of separation.

8. Whenever either of the two powers, æther and phlogiston, is *chemically* excited and separated from the other, that other at the same time, becomes equally active, and acquires che-



mical properties and affinities. Thus, nitrous acid consists of the antacid principle, with an excess of the acid principle. If it be exposed to the influence of the æthereal and phlogistic powers in the state of light, the acid particles will attract the æthereal power, and excite it to arrangement around them, by which they will be rendered aeriform and constitute pure air; and, at the same instant, the antacid particles will attract the phlogistic power and acquire a change of colour and properties. These antacid particles do not, indeed, become aeriform with their phlogiston, because there is an excess of acid still remaining to detain them in combination.

So, also, when calces of gold, silver, mercury, &c. are exposed to the action of fire, light, or electric powers, when the earthy basis of the metal acquires the phlogistic power, which restores it to its metallic lustre and properties, the acid particles which were combined with it in the state of calx, combine with the æthereal power, invariably; so that both the æthereal and



phlogistic powers acquire the excitement of chemical affinities at the same time.

9. It is evident, then, that when the æthereal and phlogistic powers are separated from a state of simple combination with each other, whatever degree or kind of excitement is imparted to the one, the other, by the same means, becomes equally and similarly excited; whether it be the magnetic, electric, or chemical arrangement and attraction which they are excited to.



#### L A W II.

*WHEN the æthereal and phlogistic powers are separated and simultaneously excited, they are capable of imparting a secondary excitement to the common powers surrounding them.*

1. When the æthereal and phlogistic powers are excited to form *electric* atmospheres; those atmospheres will diffuse themselves upon the surface of a conducting body.



2. Those atmospheres are of small extent, as is evident from this, that the two contrary atmospheres require to be brought very near each other before they can combine and disappear; and though they easily spread upon any conducting surface, they cannot communicate themselves from one body to another, unless those bodies approach very near to each other; consequently, the true electric atmosphere is of small extent from the surface it surrounds.

3. If a conductor be rendered electric by a phlogistic atmosphere, although that atmosphere will not combine with its contrary or æthereal atmosphere whose conductor is at the distance of an inch, and consequently that atmosphere is not extended half an inch from the surface of its conductor; yet it will attract a light body at the distance of many inches:—it must, therefore, have a secondary atmosphere of several inches extent, beyond the primary electric one.

4. This, however, is not properly the electric atmosphere, because it is incommunicable by it-



self; a light small body may be attracted by it, and completely immersed in it, and may still be withdrawn without any electric communication; it is only when the body has been in contact with the real, primary, electric atmosphere, that it acquires a portion of that electric atmosphere, and then is repelled; according to the general law, that similar atmospheres repel each other.

5. If two conductors, one having an electric atmosphere of the æthereal, and the other of the phlogistic power, be placed twelve inches from each other, those two contrary powers cannot combine, because they are not in contact.

If a light body be brought between them, it will be attracted by that atmosphere to whose influence it is most exposed; it will be drawn to the surface of the conductor, till it arrives at the primary atmosphere itself; it will then be charged, repelled, and attracted to the other conductor; where it will be discharged, re-electrified with the contrary electric power, and repelled; and so on, in repeated alternations; till it has dis-



charged the atmosphere of each, by conveying it to combine with the other; and till the repulsion of one, cannot propel the intervening body within the attractive atmosphere of the other.

6. It is evident, then, that the two electric atmospheres of æthereal and phlogistic powers, though of small extent themselves, have secondary or external atmospheres which communicate from one to the other, or extend around each to a great distance.

It is evident, that each power has its distinct secondary atmosphere; because each conductor will attract a light body to itself, at a considerable distance.

It is evident that the secondary atmosphere of each power in an electric state, is different from the secondary atmosphere of the other; because two bodies with similar electric and secondary atmospheres, repel each other to the extent of those secondary atmospheres; and, an external or secondary atmosphere surrounding the con-



ductor of the electric, will attract the secondary atmosphere surrounding the conductor of the rubber, so soon as those secondary atmospheres are in contact; and at a much greater distance, than that where the primary electric atmospheres came in contact and combine.

7. It is impossible, then, to deny, with any support from reason, that every body in an electric state, has a primary and secondary atmosphere surrounding it: the secondary or external atmosphere, will attract all bodies within its extent; but it is incommunicable, unless the body it attracts be brought in contact with the primary atmosphere; in which case, a portion of that primary atmosphere will diffuse itself to the approaching body, and with it a portion of the secondary atmosphere also; by which the body will be repelled, as having an electric atmosphere, similar in its principles to that of the body from which it was communicated.

8. It is evident, then, when the æthereal and phlogistic powers are separated and excited to



the electric state, that each will flow along conducting surfaces near them :—that in those states of electric excitement they are extended to a small distance from the conducting surface ; and that each will communicate a certain degree of excitement to the contrary powers present in their state of universal diffusion.

9. When the æthereal power is rendered electric, it will excite the phlogistic power in common diffusion, to form a secondary atmosphere around it ; at the same time, the phlogistic power being rendered equally electric, will excite a secondary, or external atmosphere of the commonly diffused æthereal power around it : so that the æthereal and phlogistic powers, when separated and rendered electric, give a peculiar excitement to the powers in the common state of diffusion, by which they become separated, and form secondary atmospheres attractive to each other and to matter in general.

Each external atmosphere attracts the other ; each will attract bodies within its extent, to its



respective centre ; each of them will surround another body to which a portion of its primary exciting atmosphere has been communicated by contact : each of them will repel a similar atmosphere, thus communicated to another body ; but, neither of them can pass to any other body, to which its exciting primary atmosphere has not been communicated ; neither can the two external atmospheres though formed of the contrary powers, and powerfully attractive to each other, combine, and return to their common state of diffusion, till their respective primary atmospheres by coming into contact, destroy each others electric properties and arrangement ; in which case, both primary and secondary atmospheres will combine and return to their equal state of general diffusion.

10. That the æthereal and phlogistic powers, when excited to electric arrangement, in states of separation, have the power of exciting the surrounding powers in their common state, so as to form secondary or external atmospheres around the separated powers in the electric state, is abundantly evident, from what I have now ad-



vanced ; and particularly from the more minute discussions of the subject, which I have laid before the public upon various occasions ; and that these powers in other states of excitement have similar effects upon the common powers is undeniable.

11. *Magnetism* is peculiar to iron.—If iron be deprived of its phlogiston, it loses its power of becoming magnetic. The magnetic atmospheres are, to a certainty, formed of contrary and distinct powers in arrangement : that extremity of a needle which is now pointing to the north, may, by the proper application of a magnet, be made to point to the south : consequently, either extremity of a needle is equally well adapted to become the centre of either of the magnetic powers in arrangement ; and, therefore, the needle is formed of certain principles which are capable of exciting either of the powers to magnetic arrangement ; and which principle becomes excited at either extremity, depends entirely upon the circumstances which produce that excitement.



12. The needle, then, throughout its whole extent, is equally attractive to the phlogistic and æthereal powers ; and it only becomes magnetic when its phlogistic power is peculiarly excited towards one extremity ; and its æthereal power to the other, as a constant and invariable consequence.

13. The needle, then, in its natural state, contains a certain proportion of the æthereal and phlogistic powers, attracted within its substance by its component particles.

When it is excited that æther and phlogiston are separated ; and the phlogistic power is attracted by the particles of the iron at one end of the needle and the æthereal power at the other.

The æthereal and phlogistic powers are then excited by separation and by being attracted by the particles of iron constituting the needle. The needle does not contain more æthereal and phlogistic power when magnetic, than in its natural state ; only, those powers are separated ;



one being drawn towards one extremity, the other towards the contrary.

The powers thus excited, then, are simply diffused within the substance of the iron; and are attracted and excited by every individual particle composing that needle; in consequence of which, they are not diffusible like the electric powers, which are simply excited on the surfaces of bodies.

In this state of excitement, then, in which the æthereal and phlogistic powers are simply diffused through the iron and excited by its particles, individually, each power excites its secondary atmosphere; the æthereal power collected and excited at one extremity of the needle, excites the phlogiston of the common powers, universally diffused; and the phlogistic power at the other extremity of the needle, excites its secondary atmosphere of the æthereal power, in the common state of diffusion: these secondary atmospheres are extended around each pole; each will attract iron; similar atmospheres will repel;



and the two contrary powers will powerfully attract each other. When a bar of iron has been attracted to one pole of a magnet, it cannot be repelled ; because the primary magnetic power is not diffusible ; being simply excited within the very substance of the iron, by which it is naturally attracted in a peculiar manner, and from which it is inseparable ; but, on the contrary, it will be attracted and detained, because its own powers are excited to a magnetic state ; the phlogistic power of the magnetic needle will attract the æthereal power of the iron bar, or needle, to that extremity in contact with it ; and its phlogistic power will, in consequence, become equally excited at the distant extremity ; in consequence of which, when removed, it will be found to be in a magnetic state also : only, that end which was in contact with the æthereal end of the magnet, will be phlogistic ; and the contrary end will have the æthereal power in magnetic excitement ; and those powers, thus separated within the needle, or bar of iron, will each excite a secondary atmosphere around them, at-



tractive to iron and to each other, as in the needle by which it was excited.

14. In *chemical* excitement the æthereal and phlogistic powers are equally subject to the influence of this law.

We know that the acid and alkaline principles will powerfully be attracted and combined if brought together: attraction, in all cases, is produced by the same cause; that cause is the mutual co-action, and progressive coalescence of the æthereal and phlogistic powers, in similar states of excitement; the acid and alkaline principles, therefore, in their purest, simplest, or most powerful and condensed states, have *each* its respective *power* chemically excited around it to a small extent; and those powers by mutual attraction, draw their respective principles into combination, and detain them there.

If these two principles be separated, the power chemically excited by each principle, will, then, attract a *secondary* or *external* atmo-



sphere, and assume the aeriform state ; unless one or both be still detained, or attracted by other principles in a more condensed state.

Thus nitrous acid, when separated from its combination with the antacid, or alkaline principle in various states, and by various operations, excites an external or secondary atmosphere, and forms, by that means, pure air ; and inflammable air is in many operations produced, when the alkaline principle is separated from the acid principle, and excites an external atmosphere of the phlogistic power. The calx of mercury is reduced in close vessels, by a degree of heat sufficient to remove the particles of the antacid principle, or earth of the mercury, from the acid principle, so as to destroy their attraction, by separating them beyond each others extent ; in which case, the acid particles excite an æthereal atmosphere, and form pure air ; while the antacid particles of the mercury excite the phlogistic power ; which they attract in such proportion as to restore them to their metallic state of pure mercury.



It is in numberless instances evident, that the two material principles are capable of assuming various states ; sometimes being condensed into the states of powerful acids, or alkalies ; at others being expanded into aeriform fluids ; and frequently being in various intermediate states, as they happen to be combined together, in greater or less proportions : it is evident, therefore, that these principles, at some times, possess the powers in states of simple chemical excitement ; and at others, that they acquire extensive atmospheres and expand into air ; in which state, the different principles are separated and rendered individually aeriform. Consequently, it is reasonable to suppose, that when the æthereal and phlogistic powers are *chemically* excited, they form atmospheres of small extent around their respective material principles, attracting them together ; but if they be separated, each power, at the same time, excites a *secondary* atmosphere around it, to a considerable extent, by separating and attracting the common powers, at all times present ; by which, each principle will be rendered aeriform, unless circumstances forbid.



15. I have entered minutely and largely upon this subject in my Elementary Principles of Nature; and have given my reasons for concluding, that the simple particles of matter are homogeneous: that every particle of matter is connected with and surrounded by an atmosphere of one, or other of the powers, of small extent:—that a particle of matter with an atmosphere of æthereal power, in chemical excitement, forms a particle of the alkaline principle; that particles of matter with atmospheres of *phlogiston*, chemically excited, form the acid principle; that the acid and alkaline principles thus formed mutually attract each other to chemical combination; and, that if they be separated from combination with each other, each particle, then, excites a secondary atmosphere of considerable extent; which, if not interrupted, renders the two material principles aeriform. In these states, similar atmospheres repel; and the contrary powers, or atmospheres, mutually attract each other to combination.

16. I think it allowable, then, to conclude, when the æthereal and phlogistic powers are



excited, by contact with matter, to assume either electric, magnetic, or chemical arrangements and properties, that they form, simply excited atmospheres, of *small* extent ; differing in the different kinds of excitement : that those simple atmospheres of the two kinds, whether electric, magnetic, or chemical, are attractive to each other ; that if they be separated so as to be no longer within each others influence, each power, whatever be its state of excitement, immediately excites a *secondary atmosphere*, of much *greater* extent around it ; that similar atmospheres of the same power, in all cases, repel ; and the contrary powers in similar states of excitement, are attractive to each other.



### L A W    I I I .

*THE æthereal and phlogistic powers when separated and excited by the contact and influence of material principles, acquire two tendencies or properties ; each power is excited to arrangement around its re-*



*pective material principle, and at the same time each is excited to be attractive to the other. These properties reciprocate with each other; so that as the contrary material principles attract each other to combination, their attraction to their respective powers in arrangement diminishes or ceases; and as the material principles become separated from each other, they exert their attractive influence upon their respective powers which they take into arrangement; which arrangement is more or less perfect and extensive as those material principles are more or less perfectly separated from each other.*

1. When the æthereal and phlogistic powers are excited to the *electric* state, they simply attract the electric surface to the rubber: the instant that those contiguous surfaces of the excited electric and rubber, are separated, the simple electric atmospheres are *separated* also; and then each excites its *secondary* atmosphere to extensive arrangement around it. If those secondary or external atmospheres are permitted to draw their respective internal atmospheres into contact, so soon as those primary atmospheres



attract each other into combination, the excitement of arrangement ceases; and the two external atmospheres return to their common state.

2. It is evident, then, that when the combination of the primary electric powers is destroyed by separation, each power exerts its property of arrangement, and acquires an external, extensive atmosphere; and that when those primary atmospheres can again combine, their properties of exciting the arrangement of atmospheres around them cease, and those atmospheres become disengaged.

3. As the æthereal and phlogistic powers in the electric state of excitement, form merely superficial, diffusible atmospheres, it is evident that in those states they have no peculiar attraction, confining them to the surfaces they surround; when, therefore, the two powers, forming those primary superficial atmospheres, combine, they destroy each others electric properties, and atmospheric arrangement; and with



their secondary atmospheres return to their usual mode of existence.

4. In *magnetism* the same law prevails. Iron strongly and peculiarly attracts both the æthereal and phlogistic powers, and they each other:— in this state of combination, they have *no* atmospheres. If the æther and phlogiston be *separated* by magnetic excitement, the moment that their attraction of combination ceases to operate, their attraction of arrangement takes place, and each power acquires an extensive atmosphere: and the instant that the æthereal and phlogistic powers in the magnetic state of excitement in the iron, combine and return to their usual or natural state of equal diffusion through the iron by that combination, their powers of arrangement and of exciting external atmospheres cease.

5. Magnetic atmospheres are not diffusible like the electric, because the primary atmospheres of the æthereal and phlogistic powers are excited by the attraction of the particles of the iron to those powers in a state of separation ;



those primary magnetic atmospheres, therefore, cannot remove from their respective particles of the iron, neither can they combine together in any other manner, than by attracting and mutually being attracted together, in a state of equal diffusion throughout the substance of the iron; they are essential to the iron; they never leave it; they are always attracted by it either singly or combined; and it is only when *separated* that they acquire the power of exciting *external* arrangements, of the powers, in the states of magnetic atmospheres; but their power of exciting the contrary powers to external arrangement *ceases*, the instant that they can *combine* and return to their usual state in the iron.

6. In *chemical* excitements of the æthereal and phlogistic powers this law constantly is observed. The acid and antacid principles are attractive to each other, by which attraction they will *combine* in a state of neutrality: but, whenever they are *separated*, the acid principle will immediately excite the *æthereal* power, which is always present in some state or other, to at-



mospheric *arrangement* ; and at the same time the antacid principle will excite the phlogistic power.

7. As chemical excitement is produced by the particles of matter in their pure state, in contact with either the æthereal or phlogistic power, that state of excitement and combination cannot be destroyed ; for as matter in different states enables the two powers to assume different degrees and kinds of excitement, it is reasonable to suppose, that when simple matter and either of the two powers are immediately in contact, they will produce an excitement, which nothing can overpower ; and, consequently, which cannot be destroyed.

8. Matter with the æthereal and the phlogistic powers, singly, in chemical combination or excitement, thus constitutes the two unalterable principles, of acidity and alkalinity :—these will powerfully attract each other to combination ; but, if they be separated, the acid principle will excite the æthereal power to arrangement around it ; and



the alkaline principle will acquire the property of exciting phlogiston to arrangement around it.

9. When the æthereal and phlogistic powers in simple chemical excitement, by contact with matter, are combined with each other, perfectly, they have no power of attracting other powers to secondary arrangement. If they be separated, the property of exciting the other powers to arrangement, singly, around them, instantly takes place: but, if the two principles again be brought into perfect combination, the power of exciting external atmospheres ceases; and the secondary atmosphere surrounding each principle, will become disengaged, and will therefore combine with the other. For example, either the acid or the alkaline principle, if they be in a state of separation, will attract an atmosphere of the contrary power, and become aeriform: but, if the acid and alkaline airs be mixed together, those atmospheres will draw the acid and alkaline principles together: when those principles combine, they no longer can excite, or attract their re-



pective powers in arrangement, which therefore become disengaged, and no longer atmospheric.

10. The acid and alkaline principles, then, have a strong attraction for each other; but, if they are prevented from combining, or are separated, they will attract their respective powers into atmospheric arrangement: so that each material principle has *two* modes of becoming saturated; the first is by *combination*, with its contrary material principle; and the second is, by exciting the contrary power, or the power to which each has an affinity, to assume the *atmospheric arrangement* around it.

11. But, as the attraction of combination diminishes, the power of exciting atmospheric arrangement gradually increases; for if a rod of iron be once passed over by either pole of a magnet, the natural principles of the iron will be imperfectly separated, and they will excite a secondary atmosphere of *small* extent; but, if by repeatedly drawing the magnet over the iron, the native powers of the iron be com-



pletely separated, each power will then excite an *extensive* atmosphere around it.

So also in electricity; if the common powers be imperfectly excited and separated, they will excite secondary atmospheres of small extent; but, if by continued friction between the electric and its rubber, the two powers be entirely separated, each will excite its secondary atmosphere to an extensive arrangement around it.

The same law being universal, must take place in every kind of excitement of the two powers; consequently, in the chemical excitement, it is sufficiently evident; for when the acid principle is disengaged from the alkaline principle, it excites the æthereal power to form a complete atmosphere around it, by which it is converted into *pure air*; if it be slightly attracted to combination by the antacid principle, which is not in a state, or in sufficient quantity to perfectly combine with it, its æthereal arrangement will be diminished, as in *fixed air*; and, if it be more intimately attracted to combination by the



antacid principle, which still is not in a state or proportion to perfectly combine with it, it will retain a still less proportion of its æthereal arrangement and constitute an *acid* in a state of liquidity.

12. In fact, the alkaline and acid principles, with their respective æthereal or phlogistic powers, may be combined in ten thousand various states and proportions ; in consequence of these properties of combination and arrangement of the æthereal and phlogistic powers, when chemically excited by matter, being *reciprocal*, one *diminishing* in power as the other *increases*. And the chief agent by which the material principles are separated, when combined by chemical attraction, is fire ; concerning which a few words may not be improper.



## ON FIRE.

## LAW IV.

*WHEN the æthereal and phlogistic powers are excited to secondary arrangement, by the influence of matter, and in that state of excitement, combine, and in that excited state of combination become disengaged, from matter, they will retain the power of, or the tendency to, arrangement around matter; and will, thereby, insinuate themselves into the atmospheres of any bodies near them.*

1. We know nothing of the æthereal and phlogistic powers, but when they are connected with matter.—Unconnected and unexcited by matter, they are perfectly unknown to us; and it is only when excited by matter, that they become possessed of sensible powers and activity.



2. We know that the material principles have the power of exciting those powers to arrangement;—and we know that the æthereal power in arrangement will attract the phlogistic power in a similar state.

3. If a particle of the acid principle with an æthereal atmosphere, be brought near to a particle of the antacid principle with a phlogistic atmosphere, the two powers will attract each other by combining; and they will also powerfully attract their respective material principles, so as to draw them into contact; consequently, the æthereal and phlogistic powers when excited to *attract each other*, are also *attractive* to the *material principles*.

4. The two powers, then, when excited by matter, are excited to arrangement around it; while they remain in arrangement, they are attractive to each other: being separated from matter, and retaining their excitement, they eagerly seek for matter around which they may arrange themselves; therefore, when the æthe-



real and phlogistic powers are chemically excited by matter, and combine and become disengaged from that matter, in that excited state, they have a powerful tendency to *resume* their atmospheric state around matter.

5. When the æthereal and phlogistic powers are separately exposed to the influence of the material principles, they are excited by that influence to become attractive to matter, and to each other, at the same time:—their attraction to matter is the attraction of arrangement, by which either of the powers becomes atmospheric; and their attraction to each other is the attraction of combination.

6. If, then, the two powers, thus excited by the influence of matter, be combined, and become suddenly disengaged, still, *retaining* their excitement, they must still be both attractive to each other and to *matter*, as those two tendencies are simultaneous and inseparable; consequently, the two powers will have a tendency to attract matter, and to *recover* their state of ar-



*rangement* ; they, therefore, as soon as disengaged from their former principles, powerfully insinuate themselves between particles of matter near them, whatever be their state of existence ; they will arrange themselves around those particles, or will enter into arrangement with the powers already connected with that matter ; consequently, the powers connecting those material principles together, by this accession of the disengaged powers, in the state of excitement, will be extended in their arrangement ; the particles they surround will not be so closely combined as before, hence, the *expansion* ; and, being less powerfully attracted together, by being more distant, they will become more liable to decomposition.

7. It is not consistent with my present plan to go over the ground that I have before repeatedly trodden ; I shall not, therefore, extend my observations, but only say, that fire is formed of the æthereal and phlogistic powers, in an excited state, combined together, and becoming disengaged from the material principles by which



they were excited ; as when pure and inflammable airs are exploded together, the æthereal and phlogistic powers attract each other, till the acid and antacid principles come in contact, and combine ; when the æthereal and phlogistic atmospheres become disengaged in their excited states, attracting each other. In this state of excitement, they form *fire* ; and have a tendency to *arrange* themselves around *matter*, as well as to attract each other ; and, therefore, will *attach* themselves to any kind of matter near them. If the calx of mercury be that matter, the excited æthereal power will attract and arrange itself around the particles of the acid particles, and convert them into pure air ; while the excited phlogiston will attach itself to the earth of the mercury, and restore it to its metallic state, if there be fire enough to *separate* the earth and acid.

8. If fire pass into ice, it will extend the arrangement of the powers attracting the acid and antacid principles forming the ice, till they are too extensive to retain the material



principles any longer in solid combination; and, if the quantity of disengaged æther and phlogiston, in the igneous state of excitement, be great, they will still continue to arrange themselves around the material principles, till those principles become too distant to attract each other any longer, so as to prevent the full and perfect atmospheric arrangement from taking place, when the whole is converted into vapour.

From what has been thus advanced, in a general manner, upon a subject of such great importance and extent, I draw the following general conclusions:

1st. There are *two material principles* which constitute the bases of all bodies, solid, fluid, or aeriform; which I call the *acid* and the *ant-acid*, or *alkaline* principles.

2d. There are *two powers* universally diffused, which I call the *æthereal* and *phlogistic* powers;—they are essentially distinct from mat-



ter, and, by co-operation, they produce *attraction*, which imparts motion to matter.

3d. The acid principle has a peculiar affinity with the æthereal power; by which, that power is excited to arrange itself in an atmospheric state, around the acid principle.

4th. The antacid principle has a peculiar affinity with the phlogistic power; exciting it to atmospheric arrangement around it.

5th. The *simple* particles of matter impart to the two powers the excitement distinguished by the peculiar properties which we call *chemical*.

6th. Particles of the material principles, in different states, with respect to the powers connected with them, or their connexion with each other, give to the æthereal and phlogistic powers *different* kinds of excitement; the chief of which are the *electric, magnetic, and*



*common* excitement, or that of universal expansion.

7th. Whenever the powers, in their common state of diffusion, are separately excited to any particular state, they become *atmospheric*; but, an atmosphere cannot be formed by one power in any state of excitement, without the other power, at the same time, assuming a similar state and properties.

8th. When either power is excited to any state of arrangement around matter, it *repels*, or resists the approach of another atmosphere of the same power, in a similar state of excitement, as soon as those atmospheres come into contact.

9th. When an atmosphere of the æthereal power, in any state of excitement, comes in contact with a phlogistic atmosphere, in a similar state of excitement, they *attract* each other to combination; and by that power of combi-



nation, they draw the particles of matter which they respectively surround, into combination also.

10th. When the two powers are excited by the influence of matter, to assume the atmospheric state, in any degree or kind of excitement, so soon as those excited powers are separated, each becomes capable of exciting a *secondary*, or *external* atmosphere, of considerable extent, around it; which it acquires from the powers in their common state of general diffusion; each power in its state of excitement, attracting the contrary power to become atmospheric around it.

11th. Those external atmospheres, like their primary ones, resist the approach of similar atmospheres, nearer than the point of contact; and, a secondary atmosphere of the æthereal power, attracts the secondary phlogistic atmosphere to combination.

12th. Secondary atmospheres are entirely c



pendent upon their primary atmospheres, and can neither permanently combine, nor become disengaged, till the primary atmospheres of the two contrary powers come in contact, and combine; in which case, the contrary external atmospheres will regain their freedom.

13th. Each power, by the influence of matter, acquires an attraction of *arrangement* around matter; and an attraction of *combination* to the contrary power in a similar state.

14th. Those attractive tendencies *reciprocate* with each other; so that, as the attraction of combination, between the primary atmospheres, or the contrary material principles, increases; their power of exciting external atmospheres into arrangement, diminishes; and *vice versa*.

15th. If the two powers in a state of powerful excitement, by the influence of matter, combine, and become *disengaged* from the matter by which they were excited, still, *retaining* their excitement by being in combina-



tion, they form *fire*; and, as one invariable condition of excitement is to render the *powers* disposed to attract matter and *arrange* themselves around it, as well as to attract each other, those powers in their excited state, constituting fire, will powerfully tend to attract matter and *arrange* themselves around it, so as to recover that state which was essential to their production, and is also essential to their excited state.

16th. If the æthereal and phlogistic powers excited by matter, by drawing their respective material principles into contact, regain their freedom, and in powerfully excited states combine together, they will form fire; and if abundantly copious, will have so strong a tendency to arrangement around matter, as to overpower the attraction of combination by which the particles of surrounding bodies are held together.

17th. As the powers form atmospheres of different extent, and as their degree of excite-



ment is proportionate to the extent in an *inverse ratio*, those powers may combine together in different states of excitement; and, consequently, the *fire* which they form by that combination may be in *different* states of excitement also, and its powers of action upon matter in various degrees of *intensity*.

18th. The æthereal and phlogistic powers, in their common state of equal and *universal diffusion*, are capable of being excited by those powers in certain states of peculiar excitement from matter; and particularly when they combine together in such states of high excitement as to form fire, particularly active:—the common principles thus excited, transmit that excitement in all directions, in rectilinear progression, if not interrupted; which progressive excitement constitutes *light*.

19th. If the lucific excitement passes near to the surface of a body, it is drawn out of its rectilinear course, towards the body; and its progression afterwards is not parallel with the



direction in which that excitement is propagated, by those powers, not so near to the surface of the intervening body.

This fact powerfully corroborates the preceding observations and positions; it proves that *all* bodies, being composed of the material principles, excite the common powers to *atmospheric arrangement* around them, in some state or other; though those states are not so strikingly evident as the chemical, magnetic, electric, and gravific states of arrangement; and it likewise proves that the powers excited by matter *are* capable of exciting *secondary atmospheres* around them.

20th. When the common powers propagate this lucific excitement, to atmospheres, connected with matter, which *attract* these powers; by that attraction, the lucific excitement is converted into the attraction of combination; the æthereal and phlogistic powers, therefore, combine, by this influence from matter and constitute fire; having acquired the tendency



to arrangement with matter, at the same time that they became attractive to each other, by the influence of the matter which arrested them in their lucific state of excitement.

Having thus taken a general view of the powers and principles which nature employs in her operations, and the common laws by which they are invariably governed, when co-acting with each other ; I shall now resume the subject of the 4th section.



## SECTION VII.

*On muscular contraction.*

1. **T**HE results of the investigations in the first four sections, were—

That there are two material principles; the acid and antacid principles; of which muscular fibres are formed.

That there are two powers, having each its affinity to one of the material principles; one the æthereal, the other the phlogistic power.

That those two powers, when excited by connexion with the material principles, are capable of atmospheric arrangement, and are attractive to each other.



That the brain is formed of two distinct portions ; the cerebrum and cerebellum.

That every complete or common nerve is formed from, or connected with, both the cerebrum and cerebellum.

That the cerebrum separates one of the powers from the blood ; and the cerebellum the other.

That every complete nerve being connected with both the cerebrum and cerebellum, is composed of nervous fibres from each ; therefore, every common nerve conveys both the æthereal and phlogistic powers, by fibres, distinctly extended, from each portion of the brain.

That the powers conveyed by the nerves, are essentially necessary to the production of muscular contraction.



That the blood, also, is essential to the due action of a muscle.

That the blood requires constant supplies of the acid principle with its æthereal power; and of the antacid principle, with its phlogistic power,

That the brain and nerves derive their respective powers from the blood; and their functions cease, when the blood is exhausted of those powers.

That the muscles themselves require the presence of blood, duly supplied with its material principles and powers, to enable them to act with effect.

That muscular fibres are formed of particles of the material principles, singly arranged, and simply connected together, by fibrillæ of common and simple construction.



That the particles in *muscular arrangement* are, in their common inactive state, considerably distant from each other.

That every other material particle is connected with a simple nervous filament, conveying the *phlogistic* power from one portion of the brain; while every intervening or alternating particle, is connected with a simple nervous filament, conveying the *æthereal* power from the other portion of the brain.

That the flow of these *two distinct powers* to their respective particles of matter, thus alternately arranged, with the assistance of the blood, produces muscular contraction, by *attracting* those alternate particles into contact; and,

That the *æthereal* and *phlogistic* powers, thus combining, and becoming *discharged* from their respective nerves, constitute *animal heat*.



A difficulty then occurred; as the powers flowing along the nerves could not be in an atmospheric state, and as the material particles in muscular arrangement must be considerably distinct, when not in action, how were we to account for those powers becoming so extensively atmospheric around the material particles, as to extend from one to the other; which is necessary to enable them to draw those particles into contact?

That difficulty I shall now attempt to surmount, by explanation.

2. In the 6th section, when considering the peculiar properties of the material principles, and the æthereal and phlogistic powers, in certain states of co-action, I endeavoured to prove, from various observations and facts, that it is an invariable law, when the two powers are excited and separated by the influence of the material principles, that each power in its excited state of separation, will form an atmosphere of small extent around the matter it is immediately con-



ned with; and, in those states, that each power will also excite an *external* atmosphere of greater extent around it, by communicating a *secondary* excitement to the common powers, at all times existing, in some state or other, around them.—This was particularly considered and explained as the second general law, and arguments were brought to prove that it invariably takes place whether the powers be excited to the chemical, magnetic, or electric states of arrangement; the kind of excitement depending upon the peculiar state of the material principles exciting them.

3. A nerve, then, supplying a muscle, conveys both the æthereal and phlogistic powers, from the cerebrum and cerebellum; when it arrives at the muscle, its æthereal power passes by a distinct filament to one material particle in muscular arrangement, and its phlogistic power by another nervous fibrilla, to another particle, the next we will suppose in succession, but considerably distant; a number of these parti-



cles, in alternate arrangement, forming a muscular fibre.

4. These two powers are separate, and *excited* by the vital or animating powers, when they flow along their distinct fibrillæ; because, when not excited, they do not flow to the particles in muscular arrangement.

5. These powers distinctly excited, and distinctly flowing to their respective particles in muscular arrangement, will, so soon as they are communicated to those particles, *diffuse* themselves around them in the state of small atmospheres highly excited; and each will, therefore, by the common law which always takes effect in similar circumstances, excite to secondary arrangement, a more extensive atmosphere of the contrary power; which external atmospheres the two nervous powers meet with in the blood, so necessary to their due effect.—Those *secondary* atmospheres will, therefore, *attract* each other; they will draw their respective primary atmospheres into *contact*; and



with them the particles of *matter* in *muscular arrangement*, which they respectively surround :—by that combination, the contrary powers will destroy each other's excitement and arrangement, and will combine and form fire ; which diffusing itself into the blood present, constitutes that degree of *heat* peculiar to *animal life*.

6. The excitement which is given to the æthereal and phlogistic *powers* by the *vital* or *animating* principle, then, greatly resembles the electric excitement of the same powers.—In both states the primary excited powers form atmospheres of small extent ; in both states, those atmospheres, when separated from each other's influence, acquire extensive atmospheres of the contrary powers around them, by secondary excitement ;—in both states, those secondary atmospheres around the two different powers, attract each other, and, by that attraction, draw the primary atmospheres, and the material particles they surround, into contact ; and in both states, when the two primary



atmospheres combine, they quit their atmospheric states and properties, and leave their respective material particles *deprived* of their *attractive* influence; to which particles they never had more than a flight, superficial attachment, as being communicated to them, and not excited by them.

7. Greatly as the vital and electric states of excitement, communicated to the æthereal and phlogistic powers, resemble each other, still, however, they have their differences; and one peculiarity particularly marks the distinction between them; which is, that whenever the æthereal and phlogistic powers are excited to the electric state, and separated, each, instantly, excites its secondary atmosphere which constantly attends it, and, together, they uniformly expand over *all* conducting surfaces near them, unless peculiarly attracted to one part by the contrary powers:—but, when the two powers are excited by the *animating* principle, the case is widely different, as is peculiarly evident in volition; for, when the intellectual



powers transmit excitement, by a nerve, to any particular muscle, that excitement is communicated to both the æthereal and phlogistic powers, and proceeds directly from the brain to the *muscle* whose action is determined upon; consequently, when excitement is communicated by the intellectual powers, that excitement is *confined* to the *very fibres* of the *nerves* which supply the *muscle* to be moved; and the two powers which distinctly receive that excitement, neither communicate it to contiguous nervous fibres, nor assume the atmospheric state of excitement, till they *flow* from the extremities of their respective nervous fibrillæ, to the *material* particles in muscular arrangement, in which they terminate; then, and not till then, they become subject to the common law; each assumes its primary state of arrangement, and each excites its secondary atmosphere, and resembles, in all its properties, the similar powers in the electric states of excitement.

8. Intellectual excitement, then, seems to be



propagated by the power of *animation* resident in every nerve; and that animating power only excites the æthereal and phlogistic powers subject to its influence, to become atmospheric, when it communicates them to their respective material particles, in which the animated nervous fibrillæ terminate; each power passing by its respective nervous fibrillæ to its respective material particles in muscular arrangement.

9. If, then, the vital or animating excitement be communicated to the two powers of the common nerve, those powers being mutually excited and separated, will flow from their respective nervous fibrillæ, to the material particles in muscular arrangement, in which they distinctly terminate, and around which they will arrange themselves, so as to form powerfully excited atmospheres, but of *small extent*.

It is possible that these *powers, alone*, may produce muscular contraction, by flowing in such quantities as to come within each other's



influence, when surrounding their respective material particles; but I by no means think it probable; because, if they were communicated by the nerves in such proportions as to attract each other, and their respective material particles into contact, why is the presence of the *blood*, properly supplied with pure air and phlogistic aliment, so essentially necessary to muscular action?—And, again, why should nature dispense with a general law, in this case, which she invariably observes in producing similar effects, by the same powers, in other states of excitement?—For instance, when two distant particles of matter acquire, the one a phlogistic, the other an æthereal atmosphere in an electric state, those atmospheres, invariably, attract around them secondary atmospheres of wide extent; those external atmospheres are evidently different from their primary exciting atmospheres; they may attract each other, and be separated again, unaltered, and unaffected by each other; but, the two contrary, primary atmospheres instantly destroy each other's arrangement, and electric properties, by coming



into contact. I, therefore, conclude, that the two powers, excited to flow from the nerves, to the material particles in muscular arrangement, form small excited atmospheres, which *do not* extend to each other.

10. The æthereal and phlogistic powers, then, thus excited around their respective material particles, and not being within each other's influence, will, according to the 2d general law, immediately excite the *two powers* existing in the *blood*, there present; the æthereal power excited around the 1st, 3d, 5th, &c. material particles, will excite secondary atmospheres of phlogiston, while the phlogistic power excited around the 2d, 4th, 6th, &c. particles, will excite the æthereal power of the blood, to form secondary atmospheres around them.

11. These secondary or external atmospheres being formed of the contrary powers in similar states of excitement, will, then, attract each other, as extending within each other's influ-



ence; by that attraction, they will draw their respective primary exciting powers into contact, and with them the material particles they respectively surround, till those primary atmospheres, by coming in contact, combine, and quitting their connexion with the material particles, lose their nervous excitement, and constitute fire; in which state they will pass into the blood of the muscle: by the combination of the primary atmospheres, the external atmospheres will also become disengaged, and combining in an excited state, will *not* return to their former combinations in the blood; consequently, the acid and antacid principles they were chemically combined with, will be left combined together; in a saline state, in the blood; and the necessity for fresh supplies of air and food to replace those principles, thus decomposed, must be proportionate to the degree of muscular action.

When the *material particles* are drawn so near to each other as to enable the primary atmospheres to come in contact, they must be



greatly approximated; the connecting, simple filaments, necessarily must become *curved*, or *bended aside*; the muscular fibre must become greatly *contracted* in its length, and the solid parts to which its extremities are connected, must, therefore, be brought *nearer* to each other, if the fibre were so connected; or, the length and circumference of the vessel must be *diminished*, in whose composition the fibre forms a part.

From what has been advanced, then, I draw the following general conclusions:

1st. That the cerebrum and cerebellum separate the æthereal and phlogistic powers from the blood.

2d. That the cerebrum separates one power, the cerebellum the other.

3d. That the medulla oblongata, the medulla spinalis, and every nerve proceeding from



them, are formed by the cerebrum and cerebellum.

4th. That every nerve, therefore, consists of distinct fibres from both the cerebrum and cerebellum.

5th. That every nerve contains both the æthereal and phlogistic powers; each power being connected with its distinct fibres: the fibres connected with the cerebrum conveying one power; those connected with the cerebellum the other.

6th. That these powers in the nerves are put in motion by the influence of the vital or animating powers, inherent in the brain and nerves.

7th. That the powers in the nerves thus put in motion, distinctly flow by their respective fibrillæ, to the material particles in muscular arrangement, distant from each other, but connected by simple filaments.



8th. That the particles receiving the æthereal power of the nervous fibrillæ, alternate with those connected with the phlogistic nervous fibrillæ.

9th. That these powers thus excited form atmospheres of small extent around their respective material particles.

10th. That the excited atmospheres, thus communicated from the nerves to the material particles of the muscular fibres, excite secondary and extensive atmospheres around them, which they acquire from the æthereal and phlogistic powers in the blood there present.

11th. That the external atmosphere, thus formed around each material particle, is sufficiently extensive to be within the influence or extent of the next adjoining atmosphere.

12th. That two external or secondary atmospheres thus in contact, will attract each other;



because the contrary powers forming those atmospheres alternate with each other.

13th. That by that attraction the primary atmospheres, which were immediately communicated from the nerves to their respective material particles, will be brought together, and with them the material particles themselves.

14th. That by this approximation of the material particles, the muscular fibre which they form will be shortened.

15th. That the æthereal and phlogistic powers communicated to those particles by their respective nervous fibrillæ, being thus brought into contact, will combine, and form fire; which, passing into the blood, constitutes animal heat.

16th. That the æthereal and phlogistic powers of the blood which were excited to form the secondary atmospheres, will combine also, and the acid and alkaline principles from which



they were separated, will form a neutral saline compound; which will remain commixed with the blood till separated by the glands, and expelled.

17th. And that the blood must require supplies of the æthereal acid and of the phlogisticated antacid principles, in proportion to the expenditure of those powers and principles by muscular action.

Thus, then, I explain muscular contraction of every kind; that is, the contraction of every muscular fibre I suppose to be effected by the *two powers* conveyed by the nerves, *attracting* the component *particles* of *muscular fibres* nearer to each other, in the manner, or upon the principles, or according to the general laws which I have explained (sect. 6th.) But, muscular fibres are very different from each other in one respect; which is, the mode of their being excited to action. Some muscular actions being excitable by the will; while



others act independently of it, and can neither be restrained, nor accelerated in their actions, directly, by any determination or effort of the mind.

Still, however, in all cases, the simple muscular fibre, or the simple material particles in muscular arrangement are *passive*; consequently, the reasons why certain muscles are subservient to the will, and others are not, must be sought for in the different states or conditions of the *nerves*, by whose powers the muscular fibres are contracted.

As the muscles subservient to the will, and the nerves connecting them with the brain, seem to be the simplest in their structure, I shall, first of all, direct my attention to them, under the general title of *voluntary muscles*, or muscles of volition; and, then, I shall consider the other class, or the *involuntary muscles*; by which I simply mean all the muscles, or muscular fibres, whose actions are not under



the direct influence of the will. Voluntary and involuntary I apply to the two classes, as terms of conveniency, without contending for their strict propriety.



## SECTION VIII.

*On the voluntary muscles, and the nerves by which they are connected with the brain.*

1. **T**HE voluntary muscles are chiefly those of the trunk of the body, of the legs and arms, and of the face.

2. Each voluntary muscle requires the presence of the blood with its proper principles, and the powers of the nerves, to excite it, or rather to cause it to contract; consequently, every voluntary muscle requires a *free* intercourse with both the brain and the heart, to enable it to discharge its functions; for, if the nerve which connects it with the brain be cut, it instantly ceases to contract, in obedience to the will; and if the arteries which supply it



with blood, be cut, its power of contracting is instantly weakened.

3. If the nerve be cut, and that portion below the section be irritated, irregular contractions of the muscle will be excited; because the nerve still retains its usual proportion of the æthereal and phlogistic powers, and also the property of secreting those powers from the blood:—and if the arteries be cut, which supply it with blood, it still will be capable of contracting in some degree, when it receives the nervous powers, because it still retains a portion of blood, in the numerous vessels distributed to it; and simply cutting its proper artery, in general, is not sufficient to deprive it of blood, on account of the anastomoses of the different blood vessels of neighbouring parts with each other,

4. When volition is excited in the brain, that excitement is transmitted along the nerve to the muscle, whose action is determined upon: that voluntary excitement communicated from the



brain to the common nerve, does not, however, excite the æthereal and phlogistic powers to become atmospheric *in the nerve* ; because, in that case, those powers could not pass along the simple nervous fibres to which they properly belong, without attracting each other, as being in contact ; nor without exciting the powers in the numerous nervous fibres in the same bundle, which branch off from the common trunk of the nerve to different muscles.

5. The excitement of volition, then, when transmitted to the voluntary nerve, is simply the excitement of *progression* ; that is, the æthereal and phlogistic powers, appertaining to the correspondent nervous fibrillæ, proceeding together to any particular muscle, are, simply, excited to move towards the extremities of their respective fibrillæ ; when there, they will flow to the material particles in muscular arrangement, in which those nervous fibrillæ respectively terminate :—the two powers thus excited to flow, will surround their respective material particles in an excited state ; each power will excite its



contrary power which it meets with in the arterial blood, to form an external atmosphere around it; and those external atmospheres will *attract* each other, and also their respective powers which were excited by, and communicated from, the nerves; and with them, the material particles in muscular arrangement; by which, the contraction of the muscular fibres will be effected, as already explained, sect. vii.

6. It is evident, then, that the nerves of volition arise from the brain, and are immediately exposed to the influence of the intellectual powers: that those powers determining upon the contraction of a muscle, transmit an excitement to the correspondent nervous fibrillæ, which convey the æthereal and phlogistic powers to *that* muscle: that that excitement is simply the excitement of progression, by which the two powers are made to flow towards their respective extremities: that the æthereal and phlogistic powers thus simply flowing along their respective fibres, are communicated to their respective material particles in muscular arrangement: that they



then excite secondary atmospheres which they acquire from the powers in the blood in the muscle, by which the material particles are attracted towards each other, and the muscle is shortened; and that the nerve forms a free and uninterrupted intercourse between the brain and the muscle.



## SECTION IX.

*On involuntary muscles, or the actions of the heart and vascular system; with the peculiar structure of their nerves, and the manner in which they are excited.*

1. **T**HE involuntary muscles are chiefly the heart, and vascular extremities. By vascular extremities I mean the extremities of the arteries and veins in every part of the body, whether it be the brain, the lungs, the muscles themselves voluntary or involuntary, the liver, stomach, intestines, or, in short, any part into whose composition the arteries and veins enter; for that these remote ramifications have a peculiar muscular action of their own, by which they propel the blood they contain, is too evident, too necessary to admit of a doubt; consequently, these vascular extremities must be interwoven



with muscular fibres, which form a considerable part of that class which I call involuntary muscular fibres, as acting independently of the will.

2. The action of an involuntary muscle, is, in effect, exactly the same as that of a voluntary muscle: it is merely a contraction; that contraction is simply an approximation of its constituent particles; that approximation is the effect of attraction drawing those particles towards each other; that, like every other attraction, is the effect of the æthereal and phlogistic powers in excitement, combining with each other; and those æthereal and phlogistic powers must be conveyed to the muscle by the nerves, as when they produce voluntary action by being communicated to the voluntary muscles; and the necessity of the blood, being present to assist in the operation, is too evident to need insisting on.

3. That the *nerves* communicate the *powers* which cause the involuntary muscles to contract, is evident from analogy with the voluntary muscles; it is incontestably proved, also, by



this consideration, that if the communication between the brain and the involuntary muscles be destroyed, by cutting the connecting nerves, their actions cease; not indeed immediately, because the nerves, during life, at all times, contain a considerable portion of the æthereal and phlogistic powers, and have, likewise, most probably, the power of secreting it from the blood; consequently, if the communication with the brain be destroyed, still the nerves of the involuntary muscles will be capable of being excited, so long as the powers they contain are unexhausted.

4. That the presence of the *blood* duly supplied with its æthereal and phlogistic powers, is also essentially necessary to the action of involuntary muscles, cannot be denied; because their actions are immediately weakened by the loss of blood in a considerable quantity; by the blood being destitute of pure *æthereal* air; or, by its being exhausted of the *phlogisticated* principle derived from proper aliment; consequently, not only the blood, but also the æthereal and phlo-



gistic powers, with their respective material principles, are necessary to the action of the involuntary muscles. The heart, indeed, may contract, when its auricles and ventricles are emptied of blood, because, though those cavities contain no blood, still, the arteries and nerves every where interwoven with the muscular fibres, forming the very *substance* of the heart itself, still retain their blood; and till that blood, and the nerves accompanying it, to every muscular fibre of the heart, be exhausted of their powers, the heart may be excited to contract; unless the vital principle itself, which excites those powers to motion, be destroyed.

5. I assume it then as a fact, that the involuntary muscular fibres are made to contract, by the æthereal and phlogistic powers communicated by the nerves, exciting the powers in the blood; by the attraction of which contrary powers, the component particles of the involuntary muscular fibres are drawn together, and the fibres shortened; in the same manner as the contraction of the voluntary muscular fibres is ef-



fects; and, therefore, I shall not again repeat the particulars of the process.

6. It is now proper to consider, why these involuntary muscles are *not* subject to the will, as the voluntary muscles are, since their actions are both produced, in the same manner, by the conjoint influence of the powers of the nerves and in the blood. That reason must be sought for in the conditions of the *nerves* themselves; and a slight attention to the respective nerves, supplying the two classes of muscles, will be sufficient to point out that reason.

7. It has already been observed (sect. viii. 2.) that the intercourse between the brain and the voluntary muscle must be uninterrupted; and if we examine those nerves of volition, we find that they are free, and uninterrupted in their course; but, as the influence of the brain cannot be directly transmitted to the *involuntary* muscles, it must follow, that the connecting nerves must be *interrupted* in their course between the brain and those muscles; and anatomy teaches us that



every nerve, passing from the brain to those involuntary muscles, *does* pass into one or more *ganglia*; and from those ganglia they proceed to the involuntary muscles; but, not unfrequently, that progress is again interrupted by most intricate plexuses. The ganglia are invariably found to intercept the nerves of the involuntary muscles: they are never found in any part of the course of the nerves of volition; therefore, it is a reasonable deduction, that the ganglia do interrupt the direct intercourse between the brain and the muscular fibres, whose actions are involuntary.

8. The *intercostal* or *great sympathetic nerves* are the grand source, from whence the nerves supplying the heart, and the vascular extremities of the stomach, intestines, liver, and abdominal viscera in general, are chiefly supplied; the actions of all those parts are involuntary, and the nerves by which they are supplied, are sent off from the ganglia of the intercostals. In fact, the intercostal nerves arise, commonly, from the fifth and sixth pair of the medulla oblongata,



and from *all* the *spinal nerves*, in succession, which send off branches which pass into the ganglia of the intercostals, and from thence to the muscular fibres of the heart, and vascular extremities of the parts mentioned.

9. The æthereal and phlogistic powers of the brain, then, flow along their respective nerves to the ganglia of the intercostal nerves; and from those ganglia they flow along the nerves, proceeding from them to the heart and vascular extremities.

The ganglia, then, do not intercept the flow of the two powers from the brain to the voluntary muscles; but they receive them from the brain by the nerves intervening, and then transmit them by nerves proceeding from them to the involuntary muscles; they, therefore, prevent the brain from transmitting the two powers, *directly*, by an uninterrupted course to any involuntary muscle; and they prevent impressions made upon the extremities of those nerves, from



being, *immediately*, conveyed to, or perceived by the brain.

10. The intercostal nerves, then, are, as it were, two chains of ganglia, from which the muscles are supplied, which perform the constant and involuntary actions requisite for the circulation of the blood through the heart, and the blood vessels in the stomach, intestines, liver, and, in short, all the abdominal viscera in particular. But, there are other involuntary actions of the vascular extremities, still more distant from the heart, or centre of the circulating powers by which the blood is moved; these are the arterial and venous extremities forming so large a portion of all the *voluntary* muscles *themselves*, of all the extremities: the more distant those vascular extremities are from the heart, the more necessary is the action of the muscular fibres, interwoven *with* those vascular extremities.

11. The vascular extremities, therefore, of the voluntary muscles, must have an *involuntary*



action, by which the blood is propelled through them, at all times, whether the muscle be in voluntary action or not; and as the circulation of the blood through those distant muscles must be chiefly effected by the involuntary actions of the sanguiferous vessels themselves, it is evident, that a considerable portion of nervous powers, must be constantly necessary, to keep up those actions; and, as those muscular fibres which perform those actions are involuntary, the nerves, by which those muscular fibres are supplied with power, must be intercepted by *ganglia*, in their course from the brain to those vascular extremities.

12. If we attend to the anatomy of those parts, and of the nervous system, we instantly perceive that the voluntary muscles are supplied with nerves passing through ganglia.

All the spinal nerves, which are the nerves distributed to the voluntary muscles, are formed of bundles of nervous fibrillæ, arising from both the anterior and posterior parts of the



medulla spinalis. The anterior bundles combine with the posterior, and pass free from interruption, from the medulla spinalis to the voluntary muscles; consequently, those nerves form a free intercourse between the brain and the voluntary muscles: but, the *posterior* fasciculi of nerves, arising from the medulla spinalis, *pass* into *ganglia*, before they unite with the anterior fasciculi and proceed in one common bundle to the muscles of volition.

13. The spinal nerves, distributed to the voluntary muscles, then, are formed of bundles of nervous threads arising from the anterior part of the medulla spinalis, which pass freely and without interruption to the voluntary muscles; and of bundles of nervous fibrillæ, arising from the *posterior* part of the medulla spinalis, which *pass* into *ganglia*; and from those ganglia nervous fibres proceed, and coalesce with the anterior nerves, to form the common nervous trunks which are distributed to the voluntary muscles. The anterior branches of the spinal nerves being free from interruption, convey the



powers, excited by volition, to the muscles, which are obedient to the will; and the posterior branches having passed through ganglia, are distributed to the muscular fibres of the blood vessels in the voluntary muscles to keep up their involuntary actions, without being under the influence of the will.

14. It appears very evident, then, that every nerve which passes in an *uninterrupted* course from the brain, or the medulla oblongata, or spinalis, which are formed by the cerebrum and cerebellum, to a muscle, is a nerve of volition; and that every nerve proceeding from the brain, and passing into a *ganglion*, before it is distributed to a muscle, is *not* under the power of the will, when it passes from the ganglion to the muscle to which it is distributed.

15. A nerve of volition, then, conveys the powers excited to flow along it by mental volition, in a *direct* course to the material particles in muscular arrangement; those powers flowing along their respective nervous fibrillæ, to their



correspondent muscular particles, surround them in a state of excitement; each power excites its secondary atmosphere, which is formed of the powers in the blood, and those atmospheres of the contrary powers, by attracting each other, produce the contraction of the muscular fibre, as before (sect. vii.) amply explained.

16. But, as the nerves which pass to the heart, and the extremities of the blood vessels, in every part of the system, are interrupted by passing through ganglia, the powers excited to flow from the brain to those nerves, cannot *directly proceed* further than these ganglia; from whence they flow by a regular *diffusion* along the nerves arising from those ganglia, to be distributed to the heart and vascular extremities. The flow of the excited powers to the ganglia, is an excitement sufficient to cause them to diffuse themselves along the nerves extending to the involuntary muscular fibres: by that flow the powers are accumulated in those nerves; but, the brain *cannot*, on account of the interrupting ganglia, propagate that excitement, which is necessary to



*discharge* the two powers, from the extremities of their respective fibrillæ to the muscular fibres, so as to cause them to contract.

17. The involuntary nerves, then, arising from ganglia, *constantly* receive a flow of the æthereal and phlogistic powers from the cerebrum and cerebellum, by means of the ganglia; but that is merely the flow of simple diffusion, not of excitement; for though the æthereal and phlogistic powers diffuse themselves along their respective nervous fibres, still, the energy of the vital or animating principle is wanting, to give them that excitement upon which their power of flowing in an excited atmospheric state to the muscular fibres, and causing them to contract, depends; consequently, the involuntary nerves require the application of *stimuli* to excite them to propel their powers to the muscular fibres, so as to cause them to contract; at least, the application of stimuli is necessary to excite those nerves to perform their functions with that degree of vigour which is required.



18. That this is in reality the case, is abundantly evident; for if the blood be denied the influence of atmospheric air in the lungs, the heart will *cease* to act:—when the heart has ceased its motions, the application of stimuli will excite it to *renew* them, if applied within a certain time; and in cases of suspended animation the application of pure air to the lungs, will frequently restore the involuntary actions of the *muscles* by its stimulating effects upon the *nerves*.

19. It is by no means improbable, that the powers flowing from the brain to the ganglia, may still retain excitement sufficient to produce their flow from the nervous extremities to the involuntary muscles, so as to keep up a constant action, *independent* of any stimulus; but, at the same time, it must be granted, that the application of stimuli to those nerves, *does* excite their action; and, that the constant application of the natural stimuli of pure air and proper food, is necessary to excite those involuntary actions to a *due* degree of vigour.



20. It has already been observed, (sect. vii.) that every muscular fibre, voluntary or involuntary, is made to contract by the æthereal and phlogistic powers, flowing in a state of excitement, to their respective particles of matter in muscular arrangement :—we know that certain stimuli will excite the heart to contract, even when separated from the body, immediately after its spontaneous contractions have ceased : we know that the blood, duly supplied with its requisite principles and powers, *does* excite the heart to contract in the living body : we know that the blood does *not* excite the voluntary muscles to action ; and we know that if a nerve of volition be irritated, the voluntary muscle is put into action ; consequently, the nerves of the voluntary muscles, are *not* exposed to the action of stimuli, of any kind, in the natural, healthy state, but convey the excitement of volition, directly, from the brain to the muscular fibres, without being exposed to the influence of any other exciting cause : but, on the contrary, the involuntary nerves *are* exposed to the influence of the blood, which acts as a *stimulus* ; and



that stimulus excites the nerves to propel their æthereal and phlogistic powers, in an excited state, to the muscular fibres, which causes them to contract.

21. If a nerve of volition be irritated in its course, the muscle is thrown into action ; therefore the nerves terminate, *directly*, in the muscular fibres : but if an involuntary nerve be irritated in its course, the involuntary muscle does not contract ; which proves that the nerve does *not*, directly, terminate in muscular fibres ; but, that its fibres are *again interrupted* when they reach the muscle, and then are distributed to the muscular fibres.

22. Whatever be the state which the nerves assume, when they reach the involuntary muscles, it is evident that the excitement of the trunk of the nerves stops there, when irritated ; and it is evident, that the nerves, thus distributed upon the surfaces of the blood vessels and heart, are excitable by stimuli ; and that from thence the excitement is propagated to the extremities of



the nervous fibrillæ, which immediately terminate in the material particles in muscular arrangement; so that whenever this *nervous expansion* on the surfaces of the heart and blood vessels is excited, by proper *stimuli*, that excitement is propagated by the nervous fibrillæ which proceed from this nervous expansion to the muscular fibres themselves.

23. I think it then strictly allowable to draw the following conclusions:

1st. That the nerves of volition proceed from the brain, and pass in an uninterrupted course to the material particles in muscular arrangement, without being exposed to any intervening influence.

2d. That those nerves are connected with both the cerebrum and cerebellum, and convey the æthereal power from the one, and the phlogistic power from the other, by distinct, but correspondent fibres, to their respective material par-



ticles, alternating with each other, in muscular arrangement.

3d. That the involuntary nerves pass through ganglia, before they are distributed to the muscles of involuntary action; which ganglia prevent the direct intercourse between the brain and the muscles, and render them incapable of immediately influencing each other.

4th. That involuntary nerves, like the voluntary, are connected at their origins, *previous* to their entering the ganglia, with both the cerebrum and cerebellum, and convey the æthereal and phlogistic powers by distinct, but correspondent fibres.

5th. That the involuntary nerves, proceeding *from* the ganglia, are expanded upon the *surfaces* of the heart, and vascular extremities, particularly their *internal* surfaces, and are intimately *interwoven* with each other; in which state, the nerves with their æthereal and phlogistic powers are exposed to the influence of the blood, or



such stimuli as are conveyed by the vessels, within which they are thus expanded.

6th. That from that nervous expansion, fibrillæ arise, which are distributed to the material particles in muscular arrangement.

7th. That when the æthereal and phlogistic powers of the nerves, thus mutually expanded on the surfaces of the heart and blood vessels, are excited, by the action of the blood, or other stimuli, that excitement causes them to flow by their respective fibrillæ, to the material particles in muscular arrangement, in which they terminate.

8th. That those particles being alternately arranged, the powers thus excited to flow around them, will excite the contrary powers in the blood ; by the attraction of which the muscular fibres will be made to contract, as hath already been particularly explained.



## SECTION IX.

*On the additional influx of power to the heart and vascular extremities, or to the involuntary nerves, in consequence of the exertion of the voluntary muscles.*

1. **W**HENEVER the voluntary muscles are excited to action, the contractions of the heart and involuntary muscular fibres are, proportionately, increased in strength and frequency.

2. This increased action of the involuntary muscles, is *not* the effect of *motion*; because, if the voluntary muscles be violently excited to *rigid inflexibility*, still, the actions of the heart, &c. will be instantly *increased*; consequently, the nerves which impart the attracting powers to the involuntary muscles, must receive an additional



flow of those powers from the brain, at the same time, that the powers are excited to flow from the brain to the voluntary muscles.

3. It must then follow, that the voluntary nerves have a direct *communication* with the involuntary nerves; so that the æthereal and phlogistic powers cannot flow along the former without a partial communication to the latter.

4. If we attend to the actual state of the nerves in the human body, we shall soon be convinced that such is the case; for the voluntary muscles are chiefly supplied with their nerves from the medulla spinalis; and all the spinal nerves send off branches which pass to the ganglia of the intercostal nerves.

5. The branches of the spinal nerves, then, which are sent to the ganglia of the intercostals, have a direct communication with the voluntary nerves; so that no powers can be transmitted to the voluntary muscles, without a portion of those powers passing to the intercostal nerves, and



from the ganglia of those nerves to the heart, and vascular extremities; consequently, those nerves when expanded upon the surfaces of the heart and sanguiferous vessels, by this accession of powers, are more capable of acting with vigour, and are more readily and frequently excited by the common stimulus of the blood; because this accumulation of the two powers, more quickly restores the loss of those powers when discharged to the muscular fibres, than when the nerves are less copiously supplied with them.

6. For the same reasons we may conclude, that the posterior fibres arising from the spinal marrow, and passing through ganglia, before they coalesce with the uninterrupted anterior fasciculi of nerves, to be distributed, together, to the voluntary muscles, are, also, so connected with the anterior, voluntary portions of those nerves, as to receive a flow of power, in augmentation, whenever the voluntary portions of those nerves are excited; so that the vascular actions of those muscles may be increased, for



the purpose of accelerating the flow of blood through them when in action : for, as the presence of blood is necessary to enable the voluntary muscles to act, the more those muscles are exerted, the more blood is necessary to support those exertions ; and the voluntary nerves thus communicating a part of the powers excited to flow along them to the involuntary nerves, corresponding to them, is wisely adapted to answer that necessary end.

7. *All the nerves of volition, then, do communicate by collateral branches with the intercostal nerves, which supply the heart and vascular extremities of the abdominal viscera ; and every particular nerve, supplying any voluntary muscle, communicates with the involuntary nerve accompanying it to be distributed to the extremities of the blood vessels of that muscle ; consequently, whatever quantity of the æthereal and phlogistic powers, is transmitted from the brain to the voluntary muscles, a proportionate flow of those powers must pass to the ganglia of the intercostal nerves, and from thence to the heart*



and vascular extremities of the abdominal viscera; and, at the same time, whatever voluntary muscle is excited, a proportionate flow of the two powers must pass, in addition, to the involuntary nerves accompanying the voluntary nerve excited, that the involuntary actions of the blood vessels in the muscle excited to act, may correspond to the voluntary exertion of that muscle, that the muscular fibres may be supplied with blood, in proportion to the want of it to enable the muscular fibres to contract.

8. Every voluntary nerve, then, must have its correspondent involuntary nerve, that the flow of powers from the brain may be, at all times, proportionate, to both; so that the involuntary actions by which the blood is circulated may be proportionate to the voluntary actions requiring that blood to assist in their contractions:—therefore, every voluntary nerve must intimately communicate with its correspondent involuntary nerve, either in the brain, or in some part of its course. The voluntary nerves convey their powers *directly* from the brain to the voluntary



muscle; but the correspondent involuntary nerves convey their powers to the interrupting *ganglia*, from which the powers *diffuse* themselves to all the nerves arising from those ganglia: so that the powers flowing to the ganglia of the intercostal nerves, from whatever voluntary nerve they are derived, diffuse themselves to all the parts to which those involuntary nerves extend, below the ganglia; but any of the involuntary spinal nerves accompanying the voluntary nerves in their course to the voluntary muscles, of necessity, convey their additional excitement to the vascular extremities of *that muscle only*, whose correspondent voluntary nerve is excited.

9. It hath already been observed (sect. vii.) that the nervous fibres, when excited by volition, do not transmit their respective powers in an atmospheric state; but that the *intellectual excitement* is simply a *progressive motion* of the powers along the nervous fibres; which powers only become *atmospheric*, when they pass from the *nervous extremities* to the *material particles* in muscular arrangement; because, any particular



muscle may be thrown into action by the will, without other muscles being affected, although they are supplied from the same, common, nervous trunk as the former.

10. It is evident, then, that every voluntary muscle has an immediate connexion with the brain by *distinct* nervous fibres, peculiarly appropriated to *that* muscle alone; and, that nervous fibres, distributed to different muscles, or distant muscular fibres, when excited by the flow of powers from the brain, *do not* communicate their excitement, necessarily, to the nervous fibres in the same bundle, by contiguity.

11. It is evident, however, that nerves, in some cases, *do* communicate with each other, in such manner that the one *cannot* be excited without the other; for example, the nerves which terminate in the muscles of the eyes, are distinct nerves, and distributed to parts distant from each other; yet, whenever, by volition, one eye is raised upwards, the other is raised also; which proves that the nerve which supplies the elevator which raises one eye, is connected with the



nerve which excites the muscles to elevate the other; and that one naturally cannot receive excitement from the brain, without the other. That it is not owing to the nerves arising in pairs, or being similarly excited, as passing to corresponding muscles, is very evident, from this, that the muscles which are excited to move the pupil of one eye *towards* the nose, invariably act with the muscles which move the pupil of the other eye, *from* the nose; consequently, in this case, the nerve which supplies the adductor muscle of one eye, communicates so intimately with the nerve supplying the abductor of the other, that whenever the brain by volition excites a flow of the æthereal and phlogistic powers to the one, an equal proportion at the same time flows to the other.

It is not in the eyes alone, that such nervous connexions take place; for even the nerves which supply the voluntary muscles of the distant extremities, may be so connected at their origin as to act invariably with each other. In most people the nerves which supply the muscles



of the fingers of the right hand, have no particular connexion with those of the left ; and the volition which excites the right hand muscles to act, flows to those muscles without any such flow of powers, necessarily passing to the similar nervous fibres of the left ; but there are instances of people who from their infancy never could open or shut one hand, without an involuntary action of the muscles of the other hand to open or shut it also ; neither can they move any finger or joint, of one hand, without the similar finger or joint of the other being moved in the same manner : it is evident, then, that the nerves distributed to one part may so communicate with nerves sent to another, that the excitement of the brain imparted to one is directly communicated to the other.

12. Whether the voluntary nerves communicate with the involuntary nerves in the brain, or betwixt the brain and ganglia, or send branches to the ganglia themselves, is, in general, the same in effect ; for if an additional flow of powers to the ganglia is transmitted by means



of the excitement of the voluntary nerves, that is what is necessary; as the powers will then diffuse themselves to every part, to which the involuntary nerves are distributed, from the ganglia receiving the powers derived from the excited nerves of volition.

From the preceding considerations the following general conclusions may be drawn :

1st. That all the voluntary nerves send off branches to the ganglia of the intercostal nerves.

2d. That whenever by the excitement of volition, the æthereal and phlogistic powers are transmitted from the brain, by the voluntary nerves, to produce the action of the voluntary muscles, a *proportionate* flow of those powers is communicated by those branches to the *ganglia* of the *intercostal nerves* : consequently,

3d. That the involuntary muscles, to which the intercostal nerves are distributed, must receive a flow of the æthereal and phlogistic powers



from the voluntary nerves, whenever they are excited, and in proportion to the voluntary actions they produce ;—so that,

4th. The actions of the heart, &c. are, at all times, increased by voluntary exertions, and in proportion to the degrees of those exertions, or actions.

5th. That involuntary, or posterior fasciculi of the spinal nerves, are so intimately connected with the anterior or voluntary fibres of those nerves, that the powers excited by volition to flow along the voluntary nerves, are partly communicated to the involuntary nerves accompanying them ;—consequently,

6th. That the involuntary actions of the sanguiferous vessels of a voluntary muscle, are always increased, by the powers exciting that voluntary muscle to act, and in proportion to the degree of action : therefore,

7th. That the heart and involuntary muscular



fibres of the blood vessels, thus receiving an additional flow of the æthereal and phlogistic powers, in proportion to the flow of those powers to the voluntary muscles, must be more powerfully and repeatedly *excited* to contract, by the *blood* to whose influence their nerves are exposed ; and, consequently,

8th. That the blood, by the increased actions of the heart and blood vessels, must be circulated through the system with a velocity, increased in proportion to the degree of voluntary action ; —and,

9th. That the rapidity of the circulation of the blood through a voluntary muscle in action, must still exceed the general velocity of circulation ; because, the voluntary nerves of that muscle, besides the general communication to the intercostal nerves, have a particular connexion with the involuntary nerves accompanying them to the muscle itself ; and, therefore,

10th. That the quantity of blood circulated



through the system, or to any voluntary muscle, is naturally, proportionate to the quantity that is required there, to support the actions of the muscular fibres; to the production of which muscular actions its presence is so essentially necessary.



## SECTION X.

*A general view of the nervous and sanguiferous systems, particularly with respect to their mutual dependance upon, and co-operation with, each other.*

1. **F**ROM what hath been already advanced, it is evident that the brain derives all its powers from the blood, transmitted to it from the heart ; and it is equally certain that the contracting power of the heart is derived from the nerves, which convey it from the brain ; so that the functions of the brain and nerves, depend upon the supply of blood from the heart and arteries ; and the actions of the heart and arteries, in their turn, depend upon supplies of the two powers from the brain and nerves.

2. When the heart propels its blood to the



brain, that very blood excites the brain to exercise its functions :—that blood conveys the æthereal and phlogistic powers, which are separated by the cerebrum and cerebellum ; and every new accession of blood, excites the brain to diffuse its secreted powers, by their respective nervous fibres to every part of the body.

3. So long as the brain keeps receiving due supplies of blood, of proper qualities, so long it keeps separating from that blood the æthereal and phlogistic powers ; which as constantly diffuse themselves along the nerves to every part.

4. The powers thus constantly separated by the brain, and *diffusing* themselves along the nerves, are *not* in an excited state ;—they flow by simple diffusion ; without the vital or animating powers of the brain, or nerves, being excited ; and, consequently, without the power of flowing from the nervous extremities, or of assuming an atmospheric state. It is the *simple flow* of fluids tending to an *equilibrium* ; for, as the



brain is constantly *receiving* fresh supplies of powers from the blood, these powers must *diffuse* themselves into all the nerves, but particularly *those* which are the most *exhausted*, to prevent an undue accumulation in the brain.

5. The æthereal and phlogistic powers, then, *constantly flow* to all the nerves connected with the brain, whether voluntary, or involuntary; but that is the flow of simple *diffusion*, without the vital or animating excitement; and the nerves thus become supplied with their respective powers which constitute their *excitability*:—for, if the excitement of *volition* be communicated from the brain to a voluntary nerve, that excitement instantly gives progressive motion to the powers, which flow from their extremities in an excited state, to the muscular fibres, and cause them to contract; or, if a *stimulus* be applied to the vascular expansions of the involuntary nerves, the powers distributed to those nerves will be instantly excited to flow from the nervous extremities, proceeding from those vascu-



lar expansions of the nerves, to the fibres of the involuntary muscles, and will cause them to contract.

6. So long, therefore, as the brain is supplied with *blood* of proper qualities, so long will the nerves convey the *æthereal* and *phlogistic* powers to the *heart* and *vascular extremities*; and so long as the blood is supplied with atmospheric air and proper food, so long will the heart contract, by the stimulating effects of the blood, thus duly supported, acting upon the powers transmitted from the brain to the nerves of the heart and blood vessels: so long will all the involuntary muscular fibres be excited to perform their due actions; and so long will the voluntary nerves be ready to execute the volitions of the mind, by having powers wherewith to excite the voluntary muscles to contract, with the assistance of the blood duly supplied to those muscles by the actions of the involuntary muscles.

7. The functions of the brain and nerves,



of the heart and blood vessels, of the muscular fibres voluntary and involuntary, and of every organ composed of those distinct and essential parts, in an healthy animal, will be duly performed, so long as the *blood* is duly supplied with *pure air* and *proper food*, but *no longer*.

8. It is not the purest air, the most generous food, nor the richest cordials, that, *singly* applied, can support the functions of the living body: it is not the *acid* principle in its purest state, nor the *antacid* principle in its greatest purity, that can enable the blood to support the functions of the living man; it is the acid principle, rendered *aeriform* by its atmospheric arrangement of the *aethereal power*, and the antacid principle, with its *phlogistic power* in certain proportions and states of combination, which, *together*, can support the living powers, and they only:—for if the blood be not duly supplied with *both* these principles and powers, it cannot long excite the powers in the nerves, to produce the involuntary actions, necessary for



its transmission to the brain; and when the exhausted blood does arrive at the brain, it can no longer supply those powers which the nerves require from the brain, to enable them to produce the contractions of the muscular fibres; without which, the circulation must cease, and all the functions of life depending upon it.

Since, then, constant supplies of pure air and proper food are necessary to support life, the body must be so constituted as to render those supplies desirable; and such muscular exertions as are necessary to their acquisition and application to the blood, must be excited in consequence of their *deficiency* in the system.

9. Such in reality is the case; the *deficiency* of *pure air* is productive of a *desire* to *breathe* pure air, and excites the muscles which expand the *thorax*, by which the air rushes into the lungs, and imparts its influence to the blood: and the *deficiency* of proper *food* produces the *sensation* of *hunger*, and excites such muscular exertions



as are necessary to procure proper aliment, and convey it to the stomach.

The next subject of investigation, therefore, shall be respiration.



## SECTION XI.

*On respiration, or the manner in which the muscles, subservient to the expansion of the thorax, are excited to act, in consequence of a deficiency of pure air in the blood.*

I. **R**ESPIRATION is a complex operation, in which many muscles are concerned :—what those muscles are it is not essential to my subject to particularly explain. My particular object, at present, is to show in what manner the *dilation* of the thorax is necessarily produced, for the purpose of supplying the blood with air.—The muscles of inspiration, or those which enlarge the dimensions of the thorax, are then the only muscles under consideration ; and they, indeed, are the muscles chiefly concerned in natural respiration ; for when their actions cease, the parts forming the thorax will



return to their previous states, so as to expel part of the air from the lungs, without any muscular exertion being essentially necessary.

2. The muscles, then, whose actions are particularly the subject under consideration, are chiefly the diaphragm, and the intercostals; when these muscles are excited to contract, the capacity of the thorax is enlarged, and the air rushes into the lungs, to distend them, sufficiently, to still fill up the cavity of the thorax, though enlarged:—this I call inspiration;—these I call the muscles of inspiration; and, sometimes for conveniency, the muscles which expand the lungs, without contending for the propriety of the expression.

3. When these muscles cease to act, the thorax is instantly contracted in its dimensions, by the parts returning to their natural or usual state; in consequence of which the expanded lungs will be compressed, and a volume of air will be expelled by this compression, equal to what was taken in to expand them, when the thorax was



dilated : this I call expiration, without taking into account those muscles which may, particularly on pressing occasions, assist in the discharge.

4. The muscles of inspiration are subject to the will, at least to a certain extent ; because their actions may be accelerated, or retarded by volition ; but when not controlled by the will, they act involuntarily, and, in general, unconsciously.

5. But these actions are the same, and the effects the same, whether they be involuntarily or by volition ; consequently, these actions are produced by the same means in both cases.

6. We know that a voluntary muscle is made to act, by the two powers being excited to flow along the nerves to the muscular fibres : the muscles of inspiration, then, being subject to the will, must be made to act by the powers being excited to flow along the nerves to those muscles :—but as their actions are the same



whether they be excited by volition, or involuntarily, it must follow, that these muscles of inspiration are, in all cases, thrown into action by the æthereal and phlogistic powers of the nerves, supplying these muscles, being excited to flow along their nervous fibres; and not by the stimulus of the blood acting on their extremities, as is usual in other involuntary actions.

7. When the muscles of inspiration act, air rushes into the lungs, and their action *ceases*, if that air be pure; but, if *no air* be admitted to the lungs, or that air be *impure*, their *actions continue*, or are quickly *repeated*; and those actions, or a tendency to act, continues with pain and anxiety, till pure air is admitted, or till the functions of the system are impaired.—If, again, pure air *be* admitted, the actions of the muscles of inspiration *cease*; till the air, remaining in the lungs, becomes impure, and fresh supplies of pure air be wanted.

8. It is evident, then, that it is *not* the pure air which excites the muscles of inspiration to



act; because, when it is received into the lungs, their action *ceases*: but, it is the *want* of pure air which gives rise to the excitement of the nerves, which causes those muscles to act, as is evident from the violent and quickly repeated efforts to inspire, when pure air is not admitted to the lungs, to remove that cause which keeps up the excitement of the nerves of those muscles.

9. When the muscles of inspiration act, then, the powers of the nerves supplying those muscles are *excited*; when *air* is admitted into the lungs, that *excitement* of those nerves *ceases*; if pure air be *not* admitted, the excitement is *kept up* with anxiety and pain, till the natural functions of the system are impaired.

10. Pure air, then, when admitted into the lungs, *removes* the excitement of the powers of the nerves supplying the muscles of respiration; and, when pure air is *not* admitted into the lungs, the excitement of these nerves *increases*: it is evident, therefore, that the excite-



ment of the nerves supplying the muscles of inspiration, depends upon the state of the lungs.

11. But, that state of the lungs cannot communicate its influence to the nerves of the muscles of inspiration, by means of the blood; because, that communication is instantaneous:—consequently, then, it must be the *nerves* distributed to the lungs which communicate their influence to the *nerves* of the muscles of inspiration; and upon the state of those nerves of the lungs, the excitement of the nerves of the muscles depends.

12. The muscles of inspiration act when the powers are excited to flow along their nerves. If pure air be not admitted to the lungs, that flow of excited powers to the muscles is increased:—by what?—by the influence of the nerves of the lungs:—then, when the nerves of the lungs are *not* supplied with pure air, they *increase* the excited *flow* of the powers of the nerves belonging to the *muscles* of inspiration.



If pure air *be* admitted to the nerves of the lungs, the flow of excited powers to the muscles of inspiration *ceases*: consequently, then, the pure air *takes away* from the nerves of the lungs *those powers*, which, when *not* discharged from those nerves of the lungs, are *communicated* to the nerves which supply the *muscles of inspiration*, and cause them to contract.

13. The nerves of the lungs, then, constantly receive a flow of the æthereal and phlogistic powers from the brain; when those powers *accumulate* to a certain degree, they *flow* to the *nerves* which supply the *muscles of inspiration*, and cause them to *act*; by their action, the lungs are expanded by pure air; that air *discharges* the nerves of the lungs of their powers; and by that discharge the collateral *flow* to the nerves of the *inspiratory muscles* ceases, and they *cease* to *act*:—but as the flow of the nervous powers to the lungs is constant, if pure air be denied, the powers will be accumulated in those nerves to a certain degree, when the rest will totally pass to the nerves of



the muscles of inspiration, and excite them to violent and repeated actions, either till pure air be admitted to discharge the nerves of the lungs, or till the functions of the nerves are destroyed by the want of æthereal power in the brain.

14. For what purpose is this constant and copious flow of the nervous powers to the lungs, and which are the nerves which convey them? —The nerves which are chiefly distributed to the lungs are the *par vagum*, with some branches from the intercostals, occasionally interwoven. If we cut these nerves, then, the effects they are destined to produce will be discovered by the want of them.

15. If the *par vagum* and intercostals be cut, respiration instantly becomes laborious and difficult; in a short time, the animal dies, and the lungs are found *loaded with blood*.

16. It appears, then, that the nerves of the lungs are for the purpose of keeping up the



*vascular actions* there ; of such vast importance to man ! since, as much blood passes through the lungs in any given time, as through all the arteries in the rest of the body.—The par vagum, then, is distributed to the lungs, and particularly to the pulmonary arteries and veins, to cause them to contract and propel the blood from the right to the left side of the heart ; for when those nerves are cut, the pulmonary vessels are no longer excited by the blood, sufficiently, to promote its transimission through them.

17. It is observable, that the respiration becomes laborious, as soon as those nerves are cut. Why ? Because the *powers* which naturally flowed along the par vagum, and were *discharged* in producing the vascular actions of the lungs, now *cannot flow* along those nerves, further than the extremities where they were cut ; consequently, as the nerves of the muscles of inspiration are connected with them, *those powers* must *flow* to the *muscles* of *inspiration*, in unusual proportions, and discharge



themselves there, by producing deep and unnatural actions of those muscles, till the supplies of those powers from the brain fail, and death ensues.

18. The branches of the par vagum, distributed to the lungs, then, keep up the actions of the pulmonary veins and arteries; particularly their minute ramifications in the bronchial cells:—but those actions are involuntary; consequently, those pulmonary branches of the par vagum must be *interwoven*, upon the *surfaces* of the *pulmonary veins* and *arteries*, so as to form a nervous or medullary plexus, like the other involuntary nerves; and those nervous expansions must be stimulated to excitement by the blood; which excitement being conveyed to the muscular fibres of those vessels, by the nervous fibrillæ distributed from those expansions to the muscular fibres, will cause them to contract, in the same manner as other involuntary muscles are made to contract.

19. The par vagum, then, conveys the



æthereal and phlogistic powers to the lungs; when there, those powers are excited by the blood, and with the assistance of the æthereal and phlogistic powers in the blood, produce the vascular actions of the lungs, by which the blood is propelled through them to the left auricle and ventricle of the heart.

20. But, as has already been considered and explained, (sect. vii.) the nerves convey both the æthereal and phlogistic powers to the muscles: they require the *blood* to be replete with *both* those *powers* to assist in producing muscular action; and the blood must contain *both* those powers, to enable it to *excite* the *nerves* expanded upon the surfaces of the *blood vessels*, so as to produce the involuntary actions of those vessels.

21. The blood which passes from the right side of the heart to the vascular extremities of the lungs, is naturally considerably exhausted, or nearly deprived of its acid principle and æthereal power:—that blood, then, can neither



excite the nerves expanded upon the surfaces of the blood vessels, nor enable the powers of the nerves to produce contraction of the involuntary muscular fibres, with any degree of vigour; because it *wants* the *æthereal power* to co-operate with the phlogistic power which it contains.

22. In health, then, the *æthereal* and phlogistic powers flow by the *par vagum* to the lungs:—those nerves are expanded upon the surfaces of the pulmonary veins and arteries, and are exposed to the influence of the blood; that blood having been exhausted of its *æthereal power*, in passing through the system, cannot excite those nerves to discharge themselves to the muscular fibres of those vessels, for *want* of the *æthereal power* to co-act with the phlogistic power.—In this state, the nerves *not* being excited to *discharge* their powers, and the powers still constantly flowing to them from the brain, *those powers* must be *accumulated* in those nerves of the lungs;—in consequence of that accumulation, the *redundant powers* are commu-



*nicated* to the *nerves* of the *muscles* of *inspiration*, by connecting branches:—the powers thus communicated *flow* to those *muscles*:—they contract; the thorax expands: pure air rushes into the lungs: the *æthereal power* thus supplied to the *blood*, it immediately excites the *nerves* of the *lungs*: they discharge their powers to the *muscular fibres* of the *vessels*: those muscles act and propel the blood to the heart; while the nerves of the lungs, being *discharged* of their powers, the transmission of those powers to the nerves of the muscles of inspiration, in consequence of their redundance, *ceases*, and those muscles cease to act, till the arrival of more blood deprived of æthereal power to the bronchial cells; in which case, the powers of the nerves of the lungs will again want excitement, and discharge; will again accumulate, and flow to the muscles of inspiration; and will again, by causing those muscles to act, procure the admission of pure air to the blood; without which the actions of the lungs, as well as of the heart, brain, and every part of the system, must cease.



23. It is evident, then, that the phlogistic power in the blood cannot, *alone*, excite the involuntary nerves: that for want of excitement, the powers accumulate in the nerves of the lungs; and that the powers thus accumulating are wisely communicated to the muscles of inspiration; by whose actions, the blood is supplied with that æthereal power which is wanting.

24. Another subject of consideration respecting the lungs now presents.—As the blood which is distributed to every part of the body must pass through the lungs, to receive the æthereal air, and as the quantity circulated through the system in any given period is increased in proportion to the muscular actions of the system, voluntary or involuntary, of necessity, the parts must be so constituted, that the *degree* of *action* of the vascular extremities in the lungs, shall, at all times, be proportionate to the actions of the rest of the system.—That this in reality is the case is evident to every observer; for, if the involuntary actions of the heart and



blood vessels be quickened, the actions of the lungs are more frequent; if the voluntary muscles be put into action, the respirations instantly become more quick and full; and if even a hand or a foot be *rigidly* stretched out, the breathing will be repeated at shorter intervals, in consequence.

25. It is very evident, then, that the nerves called the *par vagum* are connected with *every nerve*, voluntary or involuntary: it is very probable that they are formed of *branches* distributed from *every* distinct nerve; which branches, compacted together, form the *par vagum*, or eighth pair, arising from the basis of the brain; or, rather, arising from the more *interior* parts of the brain, where the numerous connexions with the other nerves can be more conveniently made: and it is very evident, that the fibres of the *par vagum* which pass to the *lungs*, after being thus formed by the other nerves, communicate *within* the brain, with the nerves which supply the *muscles* of *inspiration*.—In consequence of those connexions, it must follow,



that whenever the æthereal and phlogistic powers flow from the brain to any nerve, voluntary or involuntary, a *portion* of those *powers* must pass to the par vagum and to the *lungs*; consequently, whatever be the *degree* of muscular exertion in the system, the lungs will be made to receive an *equal* flow of those powers, to support their actions;—and the more *copious* that flow of powers to the lungs is, the sooner they will *accumulate* and regurgitate, or flow into the nerves of the *mufcles* of *inspiration*, to expand the lungs, and admit pure air, for the purpose of exciting the nerves of the lungs to *discharge* themselves in *vascular actions*; by which the blood, replenished with the *aerial* influence, may be transmitted to *every* part of the system, in proportion to the necessity there is for it there, to support the muscular actions.

26. That the nerves of the lungs *do* receive the powers from *every nerve*, distinctly, by a communicating *branch*, is abundantly evident from this, that, no *single* muscle can act, but the actions of the lungs are immediately in-



*creased*:—if one hand be firmly closed for a minute, the number of inspirations in that minute will be *greater* than before, *cæteris paribus*: consequently, *every* nerve, supplying any muscle, *must* send a branch to the *par vagum*, as well as to the intercostal nerves, as was before explained, sect. ix.

27. The *par vagum*, then, certainly do receive a proportion of the æthereal and phlogistic powers, from every nerve arising in, or from the brain:—they certainly also are connected with the nerves of the muscles of inspiration; and when a certain quantity of those powers is received into the nerves of the *par vagum*, they pass into the nerves of those muscles, and excite them to contract; by which the lungs are made to receive the air:—if the *discharge* of those powers from the nerves of the lungs be *prevented, entirely*, that accumulation of powers will be more speedy and great, and the flow of powers to the nerves of the lungs will be *entirely diverted* to the *muscles of inspiration*.



28. That a portion of the powers may *regularly* flow from the par vagum to the nerves supplying the muscles of inspiration, is possible; but, that the æthereal and phlogistic powers in the nerves of the lungs, when there is *not* pure air to enable the blood to excite them to discharge themselves, by *accumulation*, flow to the nerves and muscles of *inspiration*, and cause them to expand the thorax, is incontestably evident; even from this *one* consideration, that the admission of pure air to the lungs, instantly *takes away* the *excitement* of the muscles of inspiration; and, if pure air be *denied* to the lungs, the flow of the exciting powers to the nerves and muscles of inspiration is *rapid* and *excessive*; that is, when the powers *cannot* be discharged from the lungs, they *pass off* by the nerves to the muscles of inspiration: in short, that the excitement of the nerves and muscles of inspiration is derived from the nerves of the lungs I have already proved in par. 9 and 10 of this section, and shall not further insist upon what is self-evident.

29. There is one observation to be made,



of some importance, which is this.—The nerves supplying the muscles of inspiration are subservient to the will:—volition throws those muscles into action, by transmitting a flow of the æthereal and phlogistic powers from the brain along those nerves; which flow is kept up by the *vital* or *animating* powers of the nerves correspondent to, and excited by the *intellectual* powers of the brain, till those æthereal and phlogistic powers are communicated to the material particles in muscular arrangement in an *excited* state; when, becoming atmospheric around those muscular particles, they attract them together, by means of the powers in the blood, as before more particularly explained.—The *same* flow of powers, then, is transmitted to the muscles of inspiration when they act *involuntarily*; consequently, when the æthereal and phlogistic powers are *not* discharged from the nerves of the lungs, for want of pure air, and become *accumulated* in those nerves, till they flow to the nerves of the muscles of inspiration by the communicating branches, *those powers*, thus flowing to the nerves of the muscles of inspiration, excite the *vital*,



or *animating* powers of those nerves to transmit them to the muscular fibres, and cause them to act; consequently, whether the flowing powers excite the vital or animating principles of the nerves, or those principles be excited to give motion to the powers, still the effect is the same; and the excitement of the vitality or animation of a nerve, and the progressive motion of its æthereal and phlogistic powers are *simultaneous* and *mutually* productive of each other.

30. That the nervous powers may be excited to flow along the nerves, in *unusual quantities*, is evident in various parts of the system, on different occasions; and that those powers may accumulate in those nerves, and *regurgitate*, as it were, into other nerves, so as to excite them to act, is not peculiar to the nerves of the lungs alone:—for example, if the nerves of the membrane which is expanded within the nose, called, commonly, Schneider's membrane, be *slightly irritated*, the æthereal and phlogistic powers will flow in an increased quantity and excitement, and will *discharge* themselves, in exciting the



*muscular actions* of the *vascular extremities*, to an *unusual degree*; by which means, the natural secretions performed by those vessels will be greatly *increased*, and poured out upon the surface of the membrane.

If this stimulus upon the nerves be *increased*, the flow of æthereal and phlogistic powers to those nerves will be so rapid and *copious*, that they *cannot* be *discharged* by means of the muscular fibres and the blood circulating with them; the powers then *accumulate*, and flow to the nerves supplying the muscles of the *trunk*; which muscles they throw into the violent actions, which we call *sneezing*; an effect so well adapted to remove the stimulus which thus violently excited the powers to flow. Whether the excited powers passed from the nasal nerves to the nerves of the muscles thus thrown into action, by collateral branches, communicating from the nasal nerves to the other, or they excited the brain to transmit the powers to those muscles by their respective nerves, is of no consequence to determine.—That the nasal



nerves, when highly excited, produce a violent flow of powers to the *muscles* exerted in *sneezing*, is evident; that the nasal nerves have a *peculiar connexion* with the nerves of those muscles, is certain; because the excitement of the nasal nerves does *not* affect the muscles of the *extremities*, but those concerned in sneezing *only*: in what part of the brain those nerves are connected, then, is *immaterial*, so long as we know, to a certainty, that they are *peculiarly* connected with each other.

31. That the powers actually *regurgitate*, or pass from the nasal nerves to the nerves of those peculiar muscles, when they accumulate in the nasal nerves to a certain degree, is probable; because a *slight* augmentation of that flow of powers to the nasal nerves, instantly produces *increased vascular* action or secretion in the nose, which *discharges* those powers from the nerves without affecting the muscles; and it is only when the powers are excited to flow to the nasal nerves more rapidly than they *can discharge* them, that they pass to the nerves of the



muscles connected with them, and by discharging themselves from those nerves, produce the violent contraction of the muscles which constitutes sneezing.

32. It is very evident, likewise, that *one nerve* may, and does, in many instances, communicate a *portion* of its æthereal and phlogistic powers to *another nerve*, by a communicating branch, although the *other cannot*, in return, impart a portion of its powers to the *former*; for in the case of the nasal nerves, we know that when they are excited, they can communicate a flow of powers to the nerves causing the muscles to act in sneezing; but *no flow* of powers along the nerves distributed to *those muscles*, nor any kind or degree of excitement or irritation of *them*, will be communicated from them to the *nasal nerves*, so as to produce either sneezing, or any direct increase of their actions, or of the secretions effected by those actions.

33. The par vagum, then, in many circumstances, greatly *resemble* the intercostal nerves;



each receives a portion of the powers flowing from the brain by any nerve; because every nerve sends off a communicating branch to both; and both are distributed to the involuntary muscles; in consequence of which, the involuntary actions must always be proportionate to the general degree of action in the system.

34. The par vagum *differ* from the intercostal nerves in this respect,—the branches from the voluntary nerves pass into *ganglia* in the *intercostals*, before they are distributed to the involuntary muscles, or vascular extremities; and the nerves passing to the vascular extremities of distant muscles, pass through ganglia, which render them involuntary and cut off every direct communication between the brain and those muscular parts;—but, on the contrary, the par vagum do *not* pass through ganglia; they arise from the nerves directly communicating with the brain, and convey their powers, *uninterrupted*, to the parts to which they are distributed.



35. As the par vagum do not arise directly from the sensorium, they are *not* subject to *volition*; they only receive a *portion* of *all* the powers which do flow from the brain to *all* or *any other nerves*:—neither can the powers they receive, immediately excite muscular action; because the branches of the par vagum are expanded upon the *surfaces* of the vessels, in the manner of complicated medullary plexuses; there the powers *stop* in their course, till they are *excited* by the *stimulus* of the *blood*; when they flow along their respective fibrillæ, distributed from those expansions on the vessels, to the muscular fibres; which, with the assistance of the powers in the blood, they cause to contract.

36. From the preceding considerations, I draw the following general conclusions:

1st. That the par vagum, or eighth pair of nerves, are formed of branches sent off from every distinct nerve, originating in the *brain*;



which branches, collected together, constitute the *par vagum*.

2d. That whatever be the *quantity* of æthereal and phlogistic powers, flowing from the brain, to any, or all of the nerves, a *certain proportion* of those powers is necessarily transmitted to the *par vagum*, by those collateral *branches* of which they are formed ; consequently,

3d. That the *actions* of those parts to which the *par vagum* are distributed, must, necessarily, at all times, be proportionate to the actions of the system in general.

4th. That considerable branches of the *par vagum* are distributed to the *lungs*, and expanded upon the *surfaces* of the *vascular extremities* there, so as to be exposed to the action of the blood, and the air also, in the bronchial cells.

5th. That the nerves, thus expanded, receive the æthereal and phlogistic powers constantly



flowing from the brain, in some proportion or other; and, that those nervous powers, when excited by the blood, replete with phlogisticated food and æthereal acid, immediately flow along the nervous fibrillæ to the muscular fibres, and cause them to act; by which, the blood they contain is propelled from the right side of the heart, through the lungs, to the left; and the nerves are *discharged* of their powers for that time.

6th. That the blood flowing from the heart by the pulmonary *arteries*, being nearly *exhausted* of its *æthereal* acid, *cannot* excite the nerves expanded on the vascular extremities of the lungs, to flow and *discharge* themselves along the muscular fibres of those blood vessels.

7th. That the *powers*, thus constantly flowing to the nerves of the lungs, from which they are not duly excited to discharge themselves, on account of the *want* of the *æthereal* acid of the air, must soon *accumulate*, so as to prevent any further flow of those powers to the lungs.



8th. That the powers thus accumulated in the nerves of the lungs, do, then, flow by a *lateral* communication to the nerves, distributed to the *muscles* subservient to *inspiration*.

9th. That by that flow of powers, the muscles which dilate the thorax are made to act; and the air rushes into the lungs, and imparts its influence to the nerves and blood in the bronchial cells.

10th. That the *pure air*, thus received into the lungs, imparting its influence to the *blood*, restores to it that *æthereal power* which was wanting; and the nerves of the lungs are, therefore, instantly excited to transmit their powers to the muscular fibres of the blood vessels; in consequence of which, the blood is propelled through those vessels towards the left side of the heart; and the nerves of the lungs are *discharged* of their powers.

11th. That the nerves of the lungs being thus discharged, the collateral flow to the nerves



and muscles of *inspiration* will be *stopped*, and their actions will *cease*.

12th. That the air thus received into the lungs, must soon be *deprived* of its *æthereal* acid, by the flowing blood exhausted of its *æthereal* power by supporting the actions of the muscles in its circulation through the system; and, consequently, that the *succeeding* blood will *not* be capable of exciting the nerves to discharge themselves in producing the vascular actions of the lungs:—the circulation of the blood will be impeded; the powers of the nerves will accumulate; they will then regurgitate, or flow to the nerves and muscles of inspiration; *those muscles* will be thrown into *action*, and air will, *again*, be received into the lungs, and will discharge the nerves; promote the circulation of the blood, and *suspend* the flow to the muscles of *inspiration*, which will again *cease to act* as before.

13th. That if pure air be *not* admitted to the lungs, the nerves will *not* be excited to *discharge*



their powers along the muscular fibres of the pulmonary vessels ; those vessels will not be capable of *propelling* the blood ; the powers prevented from flowing off by the nerves of the lungs will be accumulated ; and the succeeding powers flowing from the brain will entirely pass to the nerves and *muscles* of *respiration* : in consequence of which, their actions will become *constant* and *excessive* ; till the *brain itself*, being deprived of its constant supplies of æthereal power, from the blood transmitted from the heart after passing through the lungs, will be so far *impaired* in its functions, as only to transmit its powers in occasional convulsive jets ; when, if the æthereal air be not admitted to the lungs, death itself must speedily ensue.

14th. That, by the nerves of the lungs being thus formed from, or at least receiving branches from, *all the other nerves* of *motion* in the system, derived immediately from the brain, the powers transmitted to the *lungs* must ever be *proportionate* to the powers transmitted to excite the muscular actions of *every other* part of the system ;



and, consequently, the vessels of the lungs will be rendered capable of transmitting as much blood, through the lungs, as is transmitted through all the muscles in the other parts of the body.

15th. And that the nerves of the lungs thus communicating with the nerves of the muscles of inspiration, will impart a flow of the powers to them proportionate to the degree of excitement or muscular action in the system; because the *more rapidly* the powers flow to the nerves of the lungs, the *sooner* will they *accumulate*, and pass to the nerves and muscles of inspiration, if not excited by the blood and æthereal air; and as the blood flowing through the lungs is naturally nearly *exhausted* of its æthereal power, and flows with a rapidity proportionate to the general degree of muscular action in the system, the more rapidly that blood is sent to the lungs, the more frequently must it require the admission of pure air to restore the æthereal power, and enable it to excite the nerves of the lungs to discharge themselves; consequently, the more frequently the



blood *wants* the *æthereal* power to excite the nerves of the lungs, the more repeatedly must the *powers* of *those nerves* regurgitate to the nerves and muscles of *inspiration* to excite them to act ; by which means the blood will acquire the *æthereal* power from the air, and discharge the nerves of the lungs, by exciting them to flow to the muscular fibres, by whose actions the blood is circulated through the lungs to the heart.

By these means the *blood*, supplied with the phlogistic power from the food taken into the stomach, acquires the *æthereal power* from the *air*, and then becomes capable of exciting the nerves expanded upon the surfaces of the vessels which convey it, to transmit those powers to the involuntary muscles, and cause them to act ; by which actions the *blood* is circulated to every part.

To the brain and nerves it imparts its *æthereal* and phlogistic powers ; and in the muscles it is the *medium* by which those powers, excited to flow from the nerves, are enabled to *attract*



the particles of matter in *muscular arrangement*, together, so as to produce what we generally call the *action* or *contraction* of the *muscles*; by which attraction also, the æthereal and phlogistic powers combining together, form *animal heat*; which, at all times, is, therefore, proportionate to the muscular actions of the system.

But, the blood requires frequent supplies of *phlogiston*, as well as of the æthereal power; in consequence of which, *proper food*, containing the *phlogistic power*, is as necessary as pure air; the next consideration, therefore, is—The digestive powers of the stomach and intestines, by which the blood is supplied with the phlogistic power combined with the antacid principle.



## SECTION XII.

*On the digestive powers of the stomach ; and the manner in which the appetite for food is excited, in consequence of a deficiency of the phlogisticated principle in the blood.*

1. **I**T has already been observed, (sect. ii. and iii.) that the reception of proper food into the stomach, is as necessary to support the functions of the brain, and the sanguiferous and muscular actions, as the admission of proper air into the lungs is ; and, that nothing is capable of affording proper nourishment, but what does contain the *phlogistic power* in a state of slight combination, and in a greater proportion than the æthereal power.

2. It has already been observed, (sect. vii.) that all actions or motions in the system, are effected by muscular fibres : that muscular fibres are made to contract by the powers of the nerves : —that the nerves convey both the æthereal and phlogistic powers ; and that those powers cannot,



naturally, be excited by the blood, to produce the involuntary actions of the system, unless the blood itself *contains* both the *æthereal* and *phlogistic powers*.

3. It has likewise been observed, that the *æthereal* power is obtained from the air, in its state of arrangement around the acid principle; and that the *phlogistic* power, when in proper states for affording nourishment to the body, is combined with the antacid principle in some state, or proportion, or other. The antacid principle, then, in those states of connexion with the *phlogistic* power, which are proper for nutrition, may be called, for the sake of conveniency, the *phlogisticated principle*.

Here let me observe, that *antacid principle* is the general term for the *contrary* to the *acid, principle*, whatever be its state; and, therefore, it includes the carbon, azote, and hydrogen of the French school, which are only *varieties* of the *same principle*, with *different* proportions of the *phlogistic* power.

4. By the wise contrivance of nature, the



world is so constituted that the antacid, alkaline, or earthy principle, with the phlogistic power, exceeds in proportion, the acid principle and its æthereal power, in general, in the animal, vegetable, and mineral systems; in all of which the *phlogistic power* particularly abounds, but is so complicated with the other power and principles, as to be condensed into states more or less solid, by chemical combination; on the contrary, the *Atmosphere alone*, is the grand and general source of *æthereal power*, and in few other states do we meet with it in an over proportion: consequently, the animal and vegetable kingdoms in particular, may afford numerous articles capable of supplying the blood with the phlogisticated power, combined in various proportions with the other principles; but, *pure air, alone*, is capable of affording the æthereal power in such a state as is adapted to the lungs, and in such proportion, as the blood requires to enable it to support the functions of the brain, and to excite the two powers in the nerves.

5. As the *phlogistic power* is capable of being



combined with the material principles in *very great* proportions, and is commonly found in those proportions in various substances, it is evident, that by means of certain aliments, the blood may be supplied with the phlogistic power in *great proportions* and quantities ; and that this is the case, is abundantly evident from this single consideration, that a man, well fed and in good health, is capable of living and exercising all his functions, for several days, without any *fresh supply* of food to the stomach ; he breathes, suppose about twelve or fourteen hogsheds of air in one day ; the blood contains phlogistic power enough to combine with and saturate, or nearly so, *all the pure air* in that quantity of atmospherical air ; consequently, were he to live seven or eight days without food, the blood must have contained as much phlogistic power as would be sufficient to saturate, or nearly saturate, *one hundred hogsheds of atmospherical air* ; a great part of which would be changed into *fire* or *heat*, as in cases of common combustion.

6. This being the case, the blood does not require such *frequent* supplies of the phlogisticated



principle, as it does of æthereal acid, or pure air; and we must now consider in what manner the system is excited to provide occasional supplies of the phlogisticated principle, when that principle is, to a certain degree, *exhausted*; or when the phlogistic power begins to be deficient in the blood.

7. The *stomach* is the receptacle of the food which is taken to support the system; and the intestines, liver, pancreas, spleen, lacteals, mesenteric glands, &c. &c. are all employed in dissolving the aliment; in selecting the nutritional parts; in expelling the useless matters, and in conveying what is proper for the support of the body to be mixed with the blood.

This process is performed by means of various fluids, secreted by glands of different descriptions, and by various vascular actions in every part of the chylo-poietic viscera.

8. The various, extensive, and constant actions of the abdominal viscera are *involuntary*,



and require a constant and copious supply of the *nervous powers* to perform them, and of *blood*, replete with the *æthereal* and *phlogistic powers* to excite them, and to assist in the action of the *muscular fibres*, by which those involuntary actions are performed.

9. The nerves which convey the *æthereal* and *phlogistic powers* to those parts, are the *intercostals* and the *par vagum*. Both these pairs of nerves are chiefly, if not entirely, formed of *branches* sent off from *all* the other *nerves of motion*, immediately connected with the brain: both of them receive a flow of the *æthereal* and *phlogistic powers*, in proportion to the *degree* of *action* in *any* or *every* part of the system; and, consequently, the actions of the stomach, bowels, &c. as well as of the heart and lungs, must correspond with the degree of action in the system.

10. That this is the case is too evident, from daily experience, to admit of a doubt; and it was wisely ordained; for as the blood is exhausted of its powers in proportion to the degree of action in the system, the actions of the stomach



and lungs, by which those powers are restored to the blood, must be, at all times, proportionate to the actions which expand them, otherwise disorder must ensue ; and the best means of keeping up that balance, was to so order it, that the very nerves which convey the powers of action to the muscles of volition, shall *transmit* a *just proportion* of those powers to the *nerves* which act for the purpose of *providing supplies* of those powers to the system at large.

11. The *vascular actions* of the stomach, intestines, liver, spleen, pancreas, lacteals, mesentery, &c. are very great and numerous ; and the quantity of *nervous powers* necessary to perform those various and extensive actions, must be great indeed ; consequently, the quantity of *blood*, duly supplied with the æthereal and phlogistic powers, must be *considerable*, to afford *excitement* to those nerves, so as to make them *discharge* their powers along the *muscular fibres*, and cause them to *contract*.

12. As the proportion of æthereal and phlo-



gistic powers flowing constantly to the nerves of the abdominal viscera, must be great, and as those powers are only excited to act by the *stimulus* of the powers in the *blood*, or *fluids* acting upon them in their states of *expansion* upon the *interior surfaces* of the blood vessels, or glands, it is evident, that when the blood becomes *exhausted*, to a certain degree, of its *phlogistic power*, it *cannot* excite the nerves to *discharge* their powers sufficiently; in consequence of which, the *vascular actions* of the abdominal viscera will be *imperfectly* performed, and the circulation *impeded*.

13. When, therefore, the phlogisticated principle becomes *deficient* in the blood, the actions, and secretions of the abdominal viscera will be *diminished*.

If, in this state, any proper food, or phlogistic matter be taken into the stomach, that *phlogiston* being applied to the nerves of the stomach, where the blood duly supplied with the æthereal power is present, will with the *conjoint influence*



of that *æthereal power*, immediately *excite those nerves* to transmit their powers to the *muscular fibres*; and the *vascular actions* will be *restored* to their *due degree* of power and efficacy.

14. As the flow of *those powers* to the nerves of the stomach is *constant*; as it is proportionate to the degree of action in the system in general; and as the desire for food is in proportion to the actions of the system, it is evident, that the *sensation of hunger*, or the *desire for food*, is produced by *those powers* in the nerves, or by the *quantity of them* present; because, the most *ardent desire* for food may be immediately *extinguished*, by taking *phlogistic* substances of certain kinds into the stomach; that is, the phlogiston those substances contain, with the *æthereal power* in the blood, together excite those nerves to *discharge* themselves.

15. It is clear, then, that when the phlogistic power is *deficient* in the blood, and the nerves of the stomach are *not discharged* of their powers, that *accumulation* of powers excites, or is the cause



of there being excited, in the nerves, the *sensation of hunger*, or the *desire for food*.

16. The *nerves* of the stomach, then, are *involuntary* in their actions, but still capable of communicating and exciting the *sensation of hunger* in the brain; they, therefore, have some *peculiarity* which distinguishes them from the involuntary nerves of the heart and blood vessels, in common;—from whence then are they derived?—in what does that difference consist?

17. The nerves of the heart and vascular extremities are chiefly supplied from the intercostals, and arise from *ganglia*, which *cut off* immediate communication with the brain; but, the nerves of the *stomach* are chiefly derived from the *par vagum*, which have *no intercepting ganglia*.

18. Both the nerves of the intercostals and par vagum, are *expanded* upon the *surfaces* of the *vessels*, and then terminate in the *muscular fibres*, which renders them *only* excitable by the application of *stimuli* to those *expansions*; but,



when a stimulus is applied to the expansions of the *par vagum*, that excitement may be communicated to the brain itself, as there are *no* interrupting ganglia.

19. That this is in reality the case, is rendered obvious by many considerations, and none is more convincing than the instantaneous excitement which is communicated to the brain and the whole system, when exhausted by fatigue, by the taking *wine* or *spirits* into the *stomach*. The *phlogistic power* in those liquids instantly excites the *nerves* of the stomach to *discharge* themselves in actuating the *muscular fibres*; and the excitement of the *nerve* is instantly communicated to the *brain*, and to *every nerve* in the system, with which the *par vagum* are connected.

20. When the formation of the *par vagum* was under consideration, in the section on respiration, it was concluded, that the *par vagum* were formed of *branches*, sent off from *all* the nerves of motion, derived immediately from the brain; consequently, though the *par vagum*



do not immediately arise from the centre of volition in the brain, still, they are simply *connected* with *all* the *nervous origins* in the brain; and, as the nerves have a peculiar *vitality* or *animation*, which rapidly conveys impressions when those nerves are free from interruption, it is evident, that when the nerves of the stomach are excited to a sufficient degree to constitute sensation, *that excitement* will be instantly communicated to *all* the *nerves* from which they arise, and from them to the *brain*; so that the *state* of the nerves of the stomach is instantly *communicated* to *all* the *nerves of motion*, and to the *brain itself*.

21. This statement is corroborated by many other facts; for we know that certain states of the stomach do affect even the voluntary muscles, in such manner as to render them active, in opposition to the will, as in *spasms* and *convulsions*, which arise from the *nerves* of the *stomach* being irritated and excited, and from that irritation and excitement being communicated to the *nerves of volition* from which they arise.



22. The branches of the *par vagum* which are distributed to the *stomach*, are not the *only nerves* which communicate their vital or animated excitement to the brain, because, the intestines themselves, are capable also of communicating certain sensations when strongly excited; and those branches which pass to the *lungs*, have the same power, as is evident from the coughing excited by irritating the lungs; from the sensation of oppression when pure air is withheld; from the pleasing relief which the admission of pure air to the lungs affords; and from the excitement which the pure air communicates to the brain by the connecting nerves in certain cases of suspended animation; for, when the functions of the brain, and the actions of the lungs have ceased, the excitement which pure air gives to the nerves of the lungs, is communicated by the vital powers of the nerves to the brain, and its functions are revived; the powers put in motion; the muscles of respiration thrown into action; the nerves of the lungs discharged, and life restored.



23. The stomach, then, receives its nerves, chiefly, from the par vagum ; and when the powers flowing constantly into those nerves from the brain, are not *duly discharged* for want of the *phlogistic power* in the blood, those powers *accumulate* and flow, more particularly, into the *nerves* which are distributed to the mouth, the tongue, the salival glands and muscles of deglutition, by a peculiar communication, similar to what takes place between the branches of the par vagum sent to the lungs, and the nerves distributed to the muscles of inspiration ; as is evident from the degree of tension, of action, of excitement, of desire for food, and from the copious secretion of saliva which accompanies that desire and the ideas which it excites.

24. It is very evident that the blood in the stomach and intestines, and their glands, and in their large appendages of the liver, pancreas, &c. must require a *great degree* of *muscular action* in the *vessels themselves* to circulate it : that muscular power must be derived from the nerves ; those nerves must be excited by the blood ; and



that blood, to be capable of exciting them, must possess *both* the *æthereal* and *phlogistic powers*, in certain proportions, otherwise the powers must *accumulate* in the nerves, and the circulation must become *slow* and *difficult*, for want of muscular action. Whenever, therefore, the *æthereal* power is wanting, nature hath wisely contrived that the powers, not being discharged from the *nerves* of the *lungs* for want of *æthereal* air, must *regurgitate* to the *nerves* and *muscles* of *inspiration*, by which means pure *æthereal* air is brought to the blood : and whenever the *phlogistic power* is wanting, it is so contrived, that the *powers*, not being *discharged* from the nerves of the stomach for want of *phlogistic power*, must *partly regurgitate* into the nerves supplying the tongue, mouth, fauces, and their peculiar glands, accompanied with the *sense of hunger*.

25. As the lungs and stomach are peculiarly destined to supply the system with the air and food, without *both* which life *cannot long* be supported, it is necessary their actions should be regulated by the *wants* of the system, or its ex-



*penditures*; and that, in cases of danger, the intellectual power itself should be alarmed, and the assistance of reason called in; for which purposes, the par vagum are connected with *all* the nerves arising from the brain, and receive a flow of the æthereal and phlogistic powers, *proportionate*, at all times, to the flow to the *rest* of the *system*; and the intercourse between the brain and extremities, or expansions of the par vagum, is *not* interrupted by *ganglia*, as is the case with the intercostal nerves; in consequence of which, powerful irritations or excitements of those *nervous expansions*, are communicated to the *brain*; more particularly so when the powers are accumulated there, while the functions of the brain are unimpaired; and, likewise, by this *free* course of the par vagum, when sudden exertions or mental emotions excite a rapid flow of powers by the nerves, a sudden flow must, *also*, pass to the lungs, stomach, heart, intestines, and every part to which the par vagum are distributed; in consequence of which, the *usual stimuli* will instantly produce a *greater action*, and at *shorter intervals*, till the increased flow is *exhausted*.



26. But, the simple vascular actions propelling the blood in a circuitous course, is not all which requires consideration, respecting the stomach. The *glandular actions* and *secretions*, and the conjoint effects of the blood, the aliment, and the nerves, require attention. They, indeed, require more attention than is compatible with my present plan; and I shall, therefore, only consider them in a general point of view.

27. The *glands* of the *stomach* are formed of arteries and veins, conveying blood, and of nerves giving motion to the muscular fibres in their texture. But, in these glands, the *blood itself* is *decomposed*, which can only be effected by the *æthereal* and *phlogistic powers* flowing off from the extremities of their respective *nervous fibrillæ*, in a state of *simple exposure* to the blood, or other fluids having access to them, *without* being *connected* with *muscular fibres*.

28. In this state of *simple termination*, the nerves are readily *excitable* by the blood or fluids acting on their extremities, and, as readily com-



communicate *that excitement* to the *brain*;—and, as both the *æthereal* and *phlogistic nerves* are *simply exposed*, it is evident, that the *degree* of excitement imparted to *either*, will *vary* as the *qualities* of the exciting *fluids* vary; and, consequently, that *either* of them may be *particularly excited*, while the *other* is *less* excited than usual.

29. It must likewise follow, that when the *æthereal* nerve is *more* excited than the *phlogistic*, the *flow* of the *æthereal power* from *that* nerve, into the *blood* or exciting fluid, will be *greater* than the flow of the *phlogistic power*; and, consequently, that the *change* produced in *those fluids* will be *different*, from what is effected when their excitements are equal, and *vice versa*; and, it must likewise follow, that the *sensations* excited and communicated to the brain, *must vary*, as the *relative excitements* of the two powers become *different* in degree.

30. The nerve which conveys the *æthereal* power, has a vital principle, which, when excited, imparts *motion* to that *æthereal power*;



consequently, it is natural to suppose, that the æthereal power *in motion* will excite the *vital principle* of that nerve; the vital principle and æthereal power being mutually subject to each other's influence. For the same reason, the *animating principle* of the nerve which conveys the phlogistic power, must be excitable by the *phlogistic power in motion* in the blood.

31. But although the *phlogistic power* in the blood, is capable of exciting the *animating principle* of the nerves which naturally convey phlogiston, it is not capable of receiving and combining with that phlogistic power of the nerves; it merely excites the *animating principle* of the nerve, which excitement is communicated to the brain; but, the phlogistic power of that nerve cannot be discharged, unless the contrary power, or the antacid principle, be present to receive it. By that excitement, however, the power of the nerve is ready to act with energy; and if the contrary power be present to receive it, it will flow from the nervous extremity and combine with that contrary power in the exciting fluid: but, if



the contrary power be *not* there in *sufficient quantity* to saturate it, it will be excited to *arrange* itself around the *antacid principle* in the *blood*, or to enter into such a state of *combination* as the circumstances will allow. In the same manner, the *vital* principle of the *æthereal* nerve may be excited by the *æthereal* power in the *blood*; in which case, the *æthereal powers* will flow from the nervous extremity, and *combine* with the *phlogistic* power if present in the blood in sufficient quantity; or, it will combine with the *acid principle* in the state of *arrangement*, or such a state as the circumstances will admit of.

32. We know that when the blood is fully supplied with the phlogistic powers, and the actions of the stomach, &c. are duly excited, the desire for food is not perceived; but, when the *phlogistic* power is considerably *expended*, the appetite returns, and increases, in proportion as the phlogistic powers become *deficient*: the *powers* sent to the nerves of the stomach and *not discharged*, then, *excite* the *sensation* of *hunger*: —but the nerves of involuntary motion in the



heart and vascular extremities of *other* parts, are *not excited to sensation* by the *accumulation* of their powers; therefore, it is reasonable, from analogy, to suppose, that it is not the *accumulation* of powers in the nerves which are distributed to the *muscular fibres* of the arterial and venous extremities, which immediately communicates to the brain the excitement of *desire* for food, but, that it is the *powers accumulated* in *those nerves*, which, without *any connexion* with muscular fibres, *simply terminate* in the *glands* of the *stomach*, and are exposed to the *influence* of the *blood*, and of the *fluids* separated from it, which excite the sensation of hunger or desire for food: and, as the appetite increases as the phlogistic power becomes deficient, to a certain degree, and as the nerves of involuntary action in the stomach become *surcharged* with powers, for want of phlogistic excitement, it is probable, that the *powers* accumulating in the *nerves* of *motion* of the stomach, *communicate* with, and *discharge* themselves, in *part*, by the *nerves* thus simply terminating in the *glands* and *inner surface* of the stomach. If the phlogistic power be ex-



hausted to a great degree, the functions of the brain and nerves will be impaired, and the powers of the stomach, of course; in consequence of which, the secretions will be *imperfect*, and the power of *digestion* confined to a small extent; but at present I am only considering the consequences of *temporary abstinence*, which does not proceed so far as to produce any material change in the œconomy of the brain and nervous system, in general.

33. If, then, a man, in health, be kept from food, but duly supplied with air, at first, he will find no inconvenience. The blood circulating to the brain, excites it to transmit a regular flow of the æthereal and phlogistic powers to all the nerves; those nerves communicate a portion of those powers to the par vagum; and part of the nerves which constitute the par vagum pass to the stomach. The nerves which are thus distributed to the stomach have *two* modes of *termination*; *one* portion of them are expanded on the *extremities* of the *blood vessels*, and, being excited by the *blood*, communicate their powers by ner-



vous fibrillæ to the *muscular fibres* of those vessels, and excite them to act; the *other portion* of those nerves, *terminate*, simply, in the *glands*, where their extremities are exposed to the *chemical action* of the *blood*.

34. While the blood, then, *abounds* with the *phlogistic* power, the powers flowing to the stomach are duly discharged, and the blood is freely circulated.—But, when phlogiston begins to be considerably *expended* and *deficient*, the nerves of the *vascular* extremities are not sufficiently excited to *discharge* themselves: so long as the functions of the brain are duly supported, and its powers abound, the flow of powers to the nerves of the stomach must continue, so long as those powers flow to any other part; they must, therefore, *accumulate* in the nerves supplying the muscular fibres of the stomach; and the flow of the powers will, then, be *chiefly diverted* to the *nerves* which *terminate* in the *glands*.

35. These nerves, simply terminating in the *glands* of the stomach, and having no *ganglia* in-



interrupting them, in their course from the brain to the glands, by this *increase* of powers will become *more sensible*, and likewise more capable of *decomposing* or *changing* the *blood*, by being excited to *discharge* their respective powers *into it* : they will, therefore, be more *excitable*, and will discharge those powers into the blood, in *greater quantities*; in consequence of which, a *greater* proportion of the *blood* will be *changed* in its properties; and those newly-acquired properties will also be more evident and efficacious, as the powers upon which they depend are more copious; to a certain extent.

36. In this state, the *glandular nerves* of the stomach will communicate their *peculiar excitement* to the brain, where it will be perceived in the sensation of *hunger*, or the *desire* for *food*; so that the flow of the æthereal and phlogistic powers from the nerves of involuntary motion in the stomach, being *prevented*, for *want* of *phlogistic power*, by this contrivance is made to *secrete* a *peculiar fluid* from the blood, which is capable of *dissolving* those substances, proper for food,



when taken into the stomach; and at the same time, the sensation of hunger is excited, by which man is powerfully urged to procure such food as is calculated to gratify that desire, and to restore to the system *that phlogistic power*, which alone is capable of removing the present state of excitement of the nerves of the stomach and of the brain, induced by the *want* of it.

37. It would carry me beyond my present purpose, to enter into a minute discussion of the chemical effects produced upon the blood and elementary substances in the stomach and intestines, and to investigate the chemical properties of the fluids secreted by the liver, spleen, pancreas, &c. I shall, therefore, only just observe, that as the secretions of the glands of the stomach are particularly excited to activity, by the *want* of *phlogistic power* in the blood, the *æthereal power* must, when the phlogistic power is considerably exhausted, be *most copious*; and the *æthereal nerves* of the glands will be *most excited*: but, as there is *not* any superabundance of loosely combined *phlogiston* in the blood, the *æthereal power* excited



to flow from those glandular nerves, will be *attracted to arrangement* by the *acid principle* in the blood, which will, therefore, acquire a *large proportion* of the *æthereal power*; and, in this state, it will *pass* into the *stomach*, *slightly connected* with the *antacid principle* with its *diminished* proportion of *phlogiston*: this *gastric fluid*, thus formed, will, when *phlogistic aliment* is taken into the stomach, immediately act upon it: the *acid principle* with its *abundant æthereal power*, will attract the *antacid principle* of the *aliment*, and combine with it, and with a *portion* of its *phlogiston*; while the *superabundant phlogiston* which all *nutrimental substances* contain, will be *attracted to arrangement* by the *antacid principle* of the *gastric fluid*, with its *small proportion* of *phlogiston*; by which means, that *antacid principle* will become again *highly phlogisticated*; and, mixing with the rest, will form a *neutral compound*, containing a *large proportion* of *phlogistic power* in a state of loose combination, fit to be received into the blood, and to restore to it its essential properties.



38. When the blood is *deficient* to a *considerable* degree in the phlogisticated principle, and the *acid* principle abounds, the nerves of the glands secrete from the blood, the *acid* principle with the *æthereal* power in *such* proportions and states of combination as to constitute an *actual acid*, as is evident in certain cases of dyspepsia, and diabetes; and, on the contrary, when *phlogiston* greatly abounds, as after taking large doses of opium or spirituous liquors, or when the *acid* principle is *deficient*, as in the scurvy, the nerves and secretions of the stomach, are in such states as to be capable of combining with and saturating large quantities of the *acid principle*.

39. The blood, thus deprived of a considerable part of its acid principle in the glands of the *stomach* and *bowels*, will retain an *unusual* proportion of the *antacid* principle, and in that state it will be conveyed by the vena portarum to the *liver*; there being exposed to the nervous extremities, in the glands of that viscus, it will of course, excite the *phlogistic nerves* of those glands in particular; they will impart a flow of the phlogistic



power, which will render the *redundant* particles of the *antacid* principle *highly phlogistic*; in which state they will pass off by the biliary ducts, combined, however, with a certain *small* proportion of the *acid particles* still remaining in the blood, in which state they will form the *bile*, a fluid replete with the phlogisticated principle, which being conveyed into the duodænum, will mix with the alimentary compound flowing from the stomach; when part of that bile will pass along with the compound chyle into the blood, and part will remain combined with the useless or superfluous parts of the aliment, whose expulsion it will assist, by its phlogistic excitement co-acting with the æthereal excitement of the blood, to *excite* the *nerves* of the intestinal canal, to keep up the regular actions of the *muscular fibres* of those parts.

40. When aliment containing a large portion of the phlogistic power is, then, received into the stomach, thus excited and thus supplied with the fluid secreted by the gastric glands in consequence of a deficiency of phlogiston in the



blood, various effects are produced:—the aliment is attacked by the *two contrary* principles of the gastric fluid: the *acid* principle with its *æthereal* power attracts the *antacid* principle of the *aliment*, while the antacid principle of the *gastric solvent* attacks the *superabundant phlogiston* of that aliment to which it has a strong attraction of *arrangement* in its present *impoverished* state: by this double attack the alimentary matters are *decomposed*, and the *phlogisticated principle* is subjected to the attractive actions of the lacteals. When the *phlogistic* power of the *aliment* is thus *evolved*, it acts also upon the nerves of the stomach; its *phlogistic* principle with the *æthereal* power of the *blood* in the vascular extremities, excite the *involuntary nerves* of those parts to impart *motion* to the *muscular fibres*, by which those nerves become *discharged* of their powers, and the blood is *propelled* with freedom; and at the same time, this *phlogistic* power, now *abundant*, excites the *animating* principle of the phlogistic nerves of the glands, which being communicated to the *brain* excites it to perform all its functions with *renewed energy*; while the quickened circula-



tion affords it more copious supplies of blood, from which it derives all its powers : and it is highly probable, that the *blood itself*, which circulates through the vessels of the stomach and intestines, does actually acquire a copious supply of the phlogistic power, when exposed to the influence of that fluid or power disengaged by the gastric solvent from the alimentary matters taken into the stomach, a considerable portion of which it retains, when transmitted from the liver to the heart, to be transmitted through the lungs to the brain and the rest of the system, upon the same principles as it attracts the æthereal power from the air, in passing through the lungs.

But not to enter more minutely into a subject of such wide extent, at present, I shall close this section by drawing the following general conclusions :

1st. That the stomach is supplied with nerves, chiefly from the par vagum.

2d. That those nerves arise from all the nerves



of motion proceeding from the brain ;—consequently,

3d. That the flow of the æthereal and phlogistic powers to the stomach, is, at all times, proportionate to the flow to the other nerves ; and, therefore, to the degree of action in the system.

4th. That the nerves of the stomach are partly distributed to the vascular extremities, where being excited by the powers in the blood or other fluids, they produce those muscular actions by which the blood is duly circulated.

5th. That other branches of those nerves are distributed to the *glands* of the *stomach*, in which they *simply terminate* ; being exposed to the influence of the blood or fluids in the stomach, without any immediate connexion with muscular fibres.

6th. That when the *phlogistic* power becomes *deficient* in the *blood*, the nerves of motion are



*not* duly *discharged*, for want of the phlogistic excitement ; and the blood, of course, is circulated with difficulty.

7th. That in consequence of this want of excitement, the powers *accumulate* in the nerves of motion, and flow, in an increased proportion, to the nerves distributed to the *gastric glands*.

8th. That the nerves of the glands, thus copiously supplied with the æthereal and phlogistic powers, are *strongly excited* by the blood in those glands.

9th. That that excitement is communicated to the brain, by those nerves being free from the interruption of ganglia ; and there it produces the *sensation* of *hunger*, or the desire for food.

10th. That the nerves of the glands thus excited and abounding in the two powers, *discharge* those *powers* in an *excited state* into the *blood*, with which they combine in various proportions, and produce *chemical changes*, from which arises



a *fluid secretion*, which passes into the stomach, and is called the *gastric fluid*.

11th. That this fluid has the property of *disengaging* the *phlogisticated principle* of the *aliment* taken into the stomach, and of combining with it, so as to form *chyle*, or a compound in which the *phlogisticated principle* forms a *considerable part*, and is *so evolved* as to be capable of exerting its specific powers, and when received into the blood, of *restoring* to it its *phlogistic* properties, and power of *exciting* the *muscular actions* of the system.

12th. That the *phlogistic* power thus evolved in the system, immediately, with the co-operation of the æthereal power in the blood, excites the *vascular actions* of the stomach, &c. and discharges those nerves of motion of their accumulated powers; by which the blood is again circulated with freedom to the heart.

13th. That, at the same time, it excites the *animating power* of the *phlogistic nerves*; which



excitement being communicated to the brain, is again transmitted to *every part* of the system ; in consequence of which, all the functions of the brain and nerves are performed with *increased energy*.

14th. That, at the same time, that the animating principle of the brain and nerves is excited by the phlogistic power in the stomach, the *motion* of the *blood* is *accelerated*, and furnishes powers in proportion to the excitement of the animating principle.

15th. That the nerves of the stomach have a peculiar communication with the nerves distributed to the tongue, salivary glands and muscles of mastication and deglutition ; in consequence of which, when the nerves of the stomach are peculiarly excited by the accumulation of powers, a portion of those powers is transmitted to the nerves of the mouth, fauces, salivary glands, &c. by which they are peculiarly excited also and ready to assist in preparing food for the stomach.

16th. That by these means the *appetite* for



food containing the phlogistic power, and the *power* of *digesting* it, is proportioned to the *expenditure* of that peculiar power by the muscular actions of the system; the *defect* of phlogistic power in the system producing such an *accumulation* of powers in the nerves of the stomach, as *excites* the *desire* for phlogistic food, which can only be *satisfied* with the application of proper *nutriment* to the stomach, already provided with a solvent capable of rendering that food fit to restore to the blood *that phlogistic power* it is in want of.

Having thus taken a general view of the natural functions of the stomach, the lungs, the brain and nerves, the heart and sanguiferous vessels, and of the muscular fibres, and the manner in which those functions are excited and exerted, I shall not enter upon any more minute consideration at present:—these are the most important parts of the system, and to enter upon the operations of less consequence would extend this tract beyond the bounds I intended.



The blood, however, is of too great importance to be overlooked; I shall, therefore, devote the next section to a few observations upon it.



## SECTION XIII.

*On the blood.*

1. **T**HE blood is the grand circulating medium, from which all the powers of the system are derived; by the assistance of which most of its operations are performed, and by whose motion and active qualities many of the actions of the system are excited.

2. The blood, naturally, contains a *large* proportion of *phlogistic power* attached to its antacid principle; but to give it a due degree of firmness or consistency, and to enable its antacid principle to retain the phlogistic power in great proportions, a certain quantity, or proportion, of the acid principle with its æthereal power in a minor proportion, are necessary.



3. That the blood does contain a large excess of phlogistic power in a natural healthy state, is evident from what has already been observed, (sect. xii. par. 5.) that a man in health consumes twelve or fourteen hogheads of atmospheric air in a day ; consequently, as a man may live several days without food, and as the air is consumed nearly in the same manner as by combustion, it is evident, that the blood must contain as much phlogistic power, in a man in good health, as would decompose nearly, or perhaps entirely, one hundred hogheads of common atmospheric air, by combining with the æthereal acid of the air, and converting it into fire, and partly into fixed air.

4. From this consideration, it is evident, then, that in common life and health the blood *does contain a large excess of phlogistic power*, in consequence of which it is capable of supporting the functions of life for a considerable time, *without fresh supplies* ; but that time is limited, and food must again be supplied, or death will ensue.



5. The blood, however, requires constant supplies of the æthereal acid, from the lungs, as well as of the phlogisticated principle from the stomach, as is evident from the fatal effects so quickly arising upon the exclusion of air from the lungs; the æthereal air being as necessary in the blood to support the functions of life, as it is to support the burning of a taper.

6. The blood being a compound in which the phlogisticated principle abounds, will, naturally, attract the æthereal acid of the atmospheric air in the lungs, as it evidently does; acquiring a more florid colour and more exciting powers than it naturally possesses when without the æthereal acid.

7. But when the antacid principle in the blood attracts the acid principle of the air, it loses its power of retaining so great a proportion of *phlogiston*: those particles of the blood, therefore, which have the opportunity of attracting the æthereal acid, will give out a portion of *phlogiston*, which, being attracted by the *antacid*



particles in the *air*, or by the adjoining particles in the blood if the former be absent, those antacid particles will, also, *combine* with a *portion* of the *æthereal air*, which will be partly *decomposed* and constitute *water*, or *fixed air*, according to the circumstances of the antacid principle, to which the phlogiston of the blood was transferred, when the æthereal acid was received into it.

By the *antacid* principle in the air and in the blood, I mean that principle which by the modern anti-phlogistians is called azote, as well as that of hydrogen.—Azote, hydrogen, and carbon, are, to a certainty, the *same principle*, only in *different states*, with respect to the *phlogistic power* arranged with them—which differences may perhaps depend upon certain portions of the acid principle in intimate combination.—The *antacid* or *alkaline principle*, therefore, I employ as a *general term*, which implies the *same principle*, whether it be in the state of earth, alkali, carbon, azote, or hydrogen—those minuter



distinctions may be useful in chemistry, but in my present subject are unnecessary.

8. Venous blood will attract the pure air from the phlogisticated air in the common atmosphere.

Phlogisticated air will attract the pure air again from that blood :—but what phlogisticated air ? —Not the phlogisticated air left when blood attracted the pure air from it, but the phlogisticated air produced by combustion.

The phlogisticated air, then, produced by *combustion* is *different* from *that* left when venous blood is exposed to common air, because, it *will* attract the æthereal acid from arterial blood, which the other *will not* ; otherwise, so soon as the blood had attracted the pure air from common air, the phlogisticated air left would attract it again ; which it does not.

How then does it differ ?—In being deprived of the æthereal acid by the *violent action* of *heat*,



and in having *attracted* into *arrangement* a large *proportion* of the *phlogistic power*; according to the third general law, (sect. vi.) that *every* chemical *principle* in proportion as it becomes *deprived* of the contrary *principle* in *combination*, acquires *that power* to which it has an *affinity*, which it excites to *arrangement*.

The phlogisticated air, then, procured by combustion, by means of its *excess* of *phlogiston*, will decompose the florid blood; it will readily impart a *portion* of that excess of *phlogistic power* to the blood, and by that means will *recover* its *attraction* to the *æthereal acid* in the blood; which *æthereal acid* will be *less forcibly* held in combination by the blood, in proportion as the *slightly* excited *phlogiston* of the *air attaches* itself to the *antacid* particles of the *blood*, containing a *less* proportion of phlogistic power than the air does, and, consequently, more attractive to it.

11. The blood, then, when exposed to the influence of the air in the lungs, acquires the *æthereal acid*, and becomes *replete* with both



the *æthereal* and *phlogistic* powers; in which state it is circulated to every part of the system. It excites the functions of the brain by its powers and motion; it imparts those *æthereal* and *phlogistic* powers to the brain and nerves; it excites the involuntary nerves expanded upon the surfaces of the vessels in which it circulates; its powers are again excited by those nervous powers flowing to the material particles in muscular arrangement, by which means, those particles are attracted towards each other, and constitute muscular contraction; and by the discharge of the nervous powers along the muscular fibres, its powers are made to combine and form fire, which diffusing itself in the blood present, constitutes the heat of animal life, which is always of course proportionate to the degree of muscular action in the system.

12. That the *æthereal* and *phlogistic* powers of the blood are thus disposed of, is evident from many considerations: both are equally necessary to support the functions of the system: both are equally required in proportion to the actions



of the system : the blood is equally deprived of them, by passing to the brain, to supply it and the nerves with powers, as it is in passing to the muscles to assist in their actions ; and both disappear in consequence of the discharge of the nervous powers along the muscular fibres, in the same manner as they do when they are exposed to the excitement of the same powers in electric states being discharged through the blood, which, from florid, is instantly changed to black; the æthereal power being expanded and excited by the electric explosion, to combine with the phlogistic power, and form heat.

13. The blood is liable to considerable changes from various circumstances ; the *proportion* of the *two material principles* may be considerably *varied*, in consequence of which its consistency and properties will be changed ; but as these considerations are more strictly pathological than physiological, I shall not at present enter into them.

14. The blood, also, in the healthy state, is



liable to a variety of changes, in consequence of its *exposure* to the immediate *influence* of the *nerves* and the *powers* which they impart to it, producing *various* fluids, with *different* properties, in the *different* glands where those new compounds are formed, and secreted from the general mass.

15. The glands differ from each other with respect to the state in which the nerves are exposed to the blood; the proportion of powers which they convey with respect to the quantity of blood in the gland; and with respect to the proportion which the æthereal and phlogistic nerves, distributed to different glands, bear to each other.

16. The secretions of the same gland may vary at different times, and in different circumstances, on account of the *different states* of the *blood*, with respect to its material principles and its powers, and their relative proportions; on account of the different proportions of the æthereal and phlogistic powers in the *brain* and



*nerves*; and on account of the degree of *stimulus* applied to the extremities of the glandular nerves themselves; to take no notice of the various causes which may arise from morbid states of the glands, or of contiguous, or connected parts.

17. That the æthereal and phlogistic powers may exist in the brain and nerves in *different proportions*, is very evident, from observing the effects of a large dose of *opium*, which is of a highly phlogistic nature; it excites the *animating principle* of the *phlogistic nerves*, and, at the same time, it *diminishes* the *excitement* of the vital *æthereal nerves*:—it *fills* the brain, the nerves, and even the blood, with its *phlogistic power*, and it exhausts the nerves, the brain, and blood, of their *æthereal power*, in a *great degree*, by *combining* with it: it *diffuses* itself by the phlogistic nerves to every part of the system: it requires *large supplies* of *pure air* to discharge it from the nerves, by exciting their respective actions: the *secretions* of the glands become *changed* by the *excess* of *phlogistic power* flowing



off from the phlogistic nerves of the *glands*; nay, even the discharges from *ulcers*, which were before the taking of the opium, *thin* and *acrimonious*, are rendered *mild*, *thick*, and *purulent*.

18. With respect to the blood, we may then draw the following general conclusions :

1st. That it consists of the antacid principle, with a large proportion of phlogistic power; rendered sufficiently firm and consistent by the intervening attraction of a small proportion of the acid principle.

2d. That the blood thus composed *chiefly* of the *phlogisticated principle*, has a power of attracting the æthereal air, when exposed to its influence in the lungs; which æthereal acid it will attract into a slight degree of combination; by which it will, however, lose a *part* of its power of attraction to the *phlogistic power*, which will, therefore, be *transferred* to *one portion* of the *air*, while the other portion of that air is taken into the blood,



3d. That the blood thus abounding in the phlogistic and æthereal powers is conveyed to every part of the system. To the brain and nerves it imparts its powers: the vital and animating principles of the involuntary nerves it excites to give motion to the heart, lungs, stomach, bowels, and, in short, to all the arterial and venous extremities in the body; and the actions of the voluntary muscles themselves, it supports, by means of its powers, which the nerves of those muscles excite to form the attractive *media*, which draw the particles of matter in muscular arrangement towards each other.

4th. That the blood immediately acts upon the simple extremities of the æthereal and phlogistic nerves, singly, terminating in the glands of different kinds; and, consequently,

5th. That as the proportion between the æthereal and phlogistic powers in the blood varies, the excitement which the blood gives to the glandular nerves must vary also; and, therefore,



6th. That as the proportions between the æthereal and phlogistic powers in the blood, or in the nerves supplied from the blood, or in both, differ, at different times, and in different circumstances, so must the secretions effected by those glands differ in consistency, activity, and in their qualities or chemical properties.

To enter more fully upon the subject of glandular secretions is, at this time, not necessary; neither shall I now stop to consider the absorbent system, any further than just to say, that the operations of the *absorbents* are chiefly dependent upon the muscular fibres in their composition, and that their actions are excited in the same manner, or upon the same principles, as the vascular actions in general; that is, by means of the blood contained in their component vessels and by the fluids they convey, conjointly exciting the involuntary nerves supplying those muscular fibres to throw them into action: in short, the absorbents in general are actuated by the same means as the *exhalents*, and they again are excited to action by the very powers which pro-



duce the vascular actions of the blood vessels, with whose extremities they are intimately connected, if exhalation is not performed by the extremities themselves.



## SECTION XIV.

*On the intellectual operations of the brain; and on the nerves distributed to the organs of sensation.*

1. **B**Y intellectual operations, I mean the various degrees and kinds of excitement of the intellectual powers of the brain, by which it perceives impressions upon the nerves of sensation, actually existing as sensations; by which it recollects former impressions, as ideas; by which it compares sensations or ideas with each other; by which it reasons and determines; and by which it executes its determinations, by transmitting power to the muscles, whose actions are subservient to those volitions.

2. The intellectual powers alone are capable of feeling, reasoning, and determining; and they alone are conscious of their existence, and



of the various kinds of excitement communicated to them.

3. The intellectual powers are not constantly excited, as is evident in sleep. They, therefore, do *not* depend upon any *one* simple principle or power, in connexion with the brain; because, if they did, so long as that connexion existed, and the brain remained unchanged, the intellectual operations would *continue* uninterrupted.

4. The intellectual powers, then, only act when they are sufficiently excited; and they are particularly excited to action by impressions made upon the nerves of sensation, and communicated by those nerves to the brain.

5. The intellectual operations, then, are excited by sensations communicated by the nerves; and when once excited, they proceed in attending to those sensations; to the ideas excited by them; and to think, reason, and act, as cir-



cumstances excite, or former experience influences.

6. But all these intellectual operations of recollection, reasoning, and determining, depend upon *prior* impressions: no man can reason, without comparing ideas; ideas cannot be compared, without recollecting them; and recollection is merely a *revival* of *former impressions*;—consequently, then, *all the operations* of the *mind* depend upon *simple impressions*; and those were imparted originally from the *nerves* of *sensation*.

7. *Sensations*, then, are simple impressions made upon the nerves, distributed to the organs of sense, by such substances as are capable of exciting those nerves, in their peculiar states of organic arrangement and connexion with matter; which sensations are communicated to the *common sensorium* by those nerves,

8. As all the nerves of sensation are derived from the same common source, and are similar



in substance, structure, and in the faculty of conveying impressions to the sensorium commune, and only differ from each other in the manner in which they are distributed, and *combined* with *matter* in the different organs to which they are extended, it is reasonable to suppose, that the *kind* of *excitement* which is given to them depends upon this *peculiar organic arrangement* and *combination* with *matter*.

9. It is reasonable, then, to conclude, that the peculiar kinds of excitement of the nerves of sensation depend entirely upon the peculiar *states* of those nerves in the *organs of sense*; and that whatever be the kind of excitement given to the powers, or animating principle of the nerves, thus peculiarly connected and arranged with matter, *that excitement* is accompanied with a *peculiar sensation*, which is communicated to the *brain*; and, consequently, as the nerves are *differently* distributed and connected with matter in the different organs of sense, they must be peculiarly liable to be excited by different kinds of matter; their *excitements* must be essentially



different; and the sensations excited in the brain by impressions upon one organ of sense, must be essentially different from all other sensations from other nerves.

10. The *powers*, then, whose action constitutes *intelligence*, seem to be extended along the nerves of sensation to the organs of sense themselves; and the peculiar *excitements* communicated to those intellectual powers, being *variously modulated* by the matter organically combined with them, excite *various sensations*, which are communicated to the sensorium commune; and this peculiar excitement *terminates* at the *origin* of the nerve excited in the sensorium commune, where it produces a certain *sensation*, or *perception*.

11. When that sensation *ceases*, by the removal of the exciting cause, still the mind or intellectual powers, in action, have the faculty of *reviving* that kind of excitement in the sensorium commune, when it forms an *idea*, or *recollection* of a former sensation: but this power



of recollection, this idea, this revival of a former sensation, depends upon the *present* excitement of the intellectual powers having some reference to, or connexion with, the nerve which communicated that sensation originally : consequently, it appears probable, that when a peculiar nerve is excited to a *certain kind* of sensation, the *animating power* of that nerve has a *tendency to repeat, or revive* the various degrees of excitement to which it *has been* accustomed ; which repetition of excitements constitutes a revival of *ideas, or recollection* of former impressions.

12. When the animating principle of a nerve, at its origin in the sensorium commune, has been *repeatedly excited* in a certain manner, whenever that nerve is excited to sensation, it will have a tendency to assume *that peculiar degree, or state* of excitement, to which it has been most accustomed, which will, therefore, present the *idea* which *corresponds* to that accustomed sensation.

13. In short, whenever the intellectual prin-



ciples or powers of the brain are excited, it is by the action of the exciting cause *in motion* imparting excitement to the *animating powers* of the *nerves*; which excitement is productive of *motion*; and the excitement and motion, *together*, are communicated to the sensorium commune of the brain.—And, as the intellectual powers of the brain are sometimes *quiescent*, and only possess intelligence when *excited to action*, it is highly probable, that *excitement* and *motion* in the *nerves* are *simultaneous* and *inseparable*: that when excitement is communicated to the sensorium of the brain, motion invariably accompanies it, as being essential to excitement; and, consequently, that the *intellectual powers* of the *brain only exist* when in a state of *excitation*; and when excited, that they are in constant *action* or *motion*.

14. In fact, it appears evident to any common observer, if he will but for a moment stop to consider:—an impression made upon a *distant* nervous extremity, may communicate a sensation to the *brain*; which may excite *various*



*ideas*; which again may terminate in *volition*, by which certain muscles are thrown into *action*.—It is evident, then, in such a case, that the impression upon the nerve of sensation produces *motion*, as well as *peculiar excitement* in the nervous extremity; *that* active excitement is rapidly conveyed to the *brain*, because the intellectual powers of the brain are *excited* so as to *recall* various *preceding* impressions in the state of *ideas*, which were communicated by *different* nerves, and, consequently, to *distant* parts of the sensorium commune; after this intellectual action, the excitement is imparted to a still *different* nerve, along which it flows with rapid *motion*, till it terminates in *muscular contraction*.

15. It appears reasonable, then, to suppose, as *motion* excites the intellectual powers to action, as that action in the brain may be communicated to this, that, and the other nerve of motion, and as that action may be excited by motion imparted to very different nerves, that the *intellectual powers*, themselves, when *excited* to action, are also excited to *motion*; that the intel-



lectual action in the *sensorium commune* is *progressive*, from one nerve to another; that *every* nerve both of sense and voluntary action, has its *distinct origin* in the *sensorium commune*; and, that the excitement communicated to the intellectual powers by one nerve, may be propagated to *any* nerve, or nerves, simultaneously, or in succession, whether nerves of sensation or volition.

16. A sensation, then, is a certain excitement communicated to a nerve, which is modified by the state of the nerve itself, in the organ of sense, and by the state or qualities of the stimulus or exciting cause acting on the nerve. Every different organization of the nerve, when exposed to the action of stimuli, will produce a different degree or kind of excitement; and what is capable of exciting one nerve, may not be in the least adapted to excite another, differently exposed and combined with the principles of the organ, or part.

Whatever be the excitement given to the



nerve, it is communicated to the brain; and every different excitement must produce a different sensation, or *perceptive motion* of the intellectual powers.

17. An idea is a kind of *revival* of the *perceptive motion* of the intellectual powers, which has formerly been excited by a nerve; and when two or more sensations, or ideas, have been frequently excited *together*, or in constant *succession*, whenever one of those sensations or ideas is excited, the other ideas are perceived to arise in the mind, in regular order, in consequence; and if a certain idea or sensation has frequently been excited in the brain, and as constantly has terminated in the *exertion* of a *certain muscle*, or *muscles*, whenever that idea is again excited, the intellectual actions will impart a flow of powers to that *nerve of motion*, unless other sensations, or ideas occur, to prevent it.

18. It appears evident, then, that the intellectual powers are excitable by matter, producing motion in those powers; and that *that* motion may



be propagated to any or every nerve originating in the sensorium commune; and from thence to any or every voluntary muscular fibre in the body.

The powers of other bodies act upon the powers of the nerves of sense; they act upon the intellectual powers; and those again upon the muscles:—but, the nerves certainly act by means of the *æthereal* and *phlogistic* powers; when those powers of the nerves are excited to act on the brain, the intellectual powers are excited; and intellectual excitement sent to the muscles is still a flow of the *æthereal* and *phlogistic* powers.

19. It appears highly probable, then, that the *intellectual* powers of the brain are entirely *dependent* upon the *æthereal* and *phlogistic* powers *there*; and that probability is rendered certain by the fact, that the intellectual operations immediately *cease*, if the brain be *deprived* of either the *æthereal* or *phlogistic* power, or *both*; as is too well known to need further attention.



20. We know that a strong exertion of the intellectual powers will, if long continued, induce great fatigue, and exhaust the æthereal and phlogistic powers of the brain: we know that in such a state of exhaustion *sleep* will restore those powers to the brain, if æthereal air and proper nourishment are not deficient:—it is evident, then, that the *intellectual* operations themselves require both the *æthereal* and *phlogistic* powers; and that those powers are *consumed* by intellectual action, but *accumulate* in sleep.

21. The sensorium commune, then, must be connected with *those parts* of both the cerebrum and cerebellum, which are particularly formed for the purpose of *separating* the æthereal and phlogistic powers from the blood:—the *æthereal* power then is conveyed to the sensorium commune by *one* set of nerves or medullary fibres; the *phlogistic* power by *another*.

22. We have, on many occasions, observed, that the powers of a nerve of volition are *qui-*



*escent*, till the *vital* principle is *excited*; and, consequently, then, it is reasonable to suppose, that the powers flowing by their respective nervous or medullary conveyances to the sensorium commune, may still *remain* and *accumulate* there, if the sensorium be *not* excited.

23. *Sleep*, then, seems to be that state of the sensorium in which there is no *sufficient excitement*, capable of producing a full *flow* of the æthereal and phlogistic powers from their distinct *sources*, (21) into the *sensorium*. A slight excitement may produce a partial flow of the two powers, with imperfect and ill-connected ideas, as we find occasionally, and which we call *dreaming*, but the *full* exertion of the intellectual powers requires the *free flow* of the æthereal and phlogistic powers from their respective sources; by which means, the sensorium is *replete* with the *two powers*, and every excitement communicated by the nerves of sensation is perceptible.

24. The intellectual principles, then, are peculiarly resident in the sensorium commune:



they are excited to attention and perception by impressions on the nerves of sensation, being communicated to the sensorium: that excitement when in a sufficient degree is communicated to the animating principles of the *medullary fibres* which *supply* the *sensorium* with the *æthereal* and *phlogistic powers*:—those contrary powers then *flow* to the sensorium, in proportion to the *excitement there*; by which means the sensorium is not only excited, but it can *act* with *energy*, till that supply of powers is *exhausted*, by the intellectual operations *combining* them *together* in the brain, or *transmitting* them to the nerves of *motion*.

25. The intellectual principles, then, *cannot* act without the two powers derived from the blood; and those powers are *quiescent*, unless the *intellectual* principles be *excited* to put them in *motion*.

Intellectual operations, then, are produced by the *conjoint* influence of the *intellectual principles* and the *æthereal* and *phlogistic* powers; by



those operations the powers are combined and converted into *fire* or *heat*; and by that change of state the sensorium becomes gradually *exhausted* of those powers, in their state of separation, necessary to produce intellectual action; in consequence of which, intellectual excitement naturally *ceases*, for *want* of powers; and when the excitement in the sensorium ceases, the *powers* no longer *flow* into it, but gradually *accumulate* in their respective fibres, till they again, by the secretions of their respective *sources*, become so abundant as to be ready to flow into the sensorium, in consequence of excitement being transmitted by the nerves, or of their own accumulation.

26. It is not the brain *alone* which acquires a store of powers by quiescence, the nerves of sensation and voluntary motion also, acquire them by secretion, or separation from the blood, circulating in their external coverings; in consequence of which, they also become *more excitable* by means of *sleep*, and impart impressions with redoubled energy: those impressions or



excitements being transmitted to the *sensorium*, will be readily conveyed to the *sources* of its *powers*, and those *powers* will *flow* into the *sensorium* in consequence ; by which the *intellectual operations* will become generally *excited*, and all the powers of the mind in readiness to *act*, as circumstances may require.

27. When the *sensorium* is thus supplied with powers, and the intellectual principles are excited to act with those powers, every peculiar excitement imparted by the nerves of sense is perceptible, with a sensation, correspondent to the state and degree of excitement ; and whatever *part* of the *sensorium* is excited, *it* has a natural tendency to *repeat*, or pass into *those states* of excitement to which it has been *accustomed*, if the sensorial attention be not excited to a different part ; in consequence of which, *previous sensations* may again be revived, under the form of *ideas* :—two or more sensations, or ideas, may also so frequently recur together, or follow one another, that whenever *one* is excited the *other* is revived also ; and two simultaneous ideas may so



frequently occur, and so constantly produce a *third*, that, whenever those two again are revived in the sensorium, the *third* is also revived as a natural consequent.

28. In fact, one grand property of the intellectual principles, when excited to action, is, that *previous sensations* are *revived* and *perceived* as *ideas*; a succession of sensations may be revived and perceived as a chain of ideas; two or more perceptions being constantly and repeatedly followed by a third, will be revived as cause and effect; in short, upon this peculiar property of *repetition* of *sensorial actions*, or *revivifications* of *sensations* as *ideas*, singly, or in association, *all* the functions of the intellectual powers, which we call mind, depend.

29. It is not my intention to enter minutely upon a subject so intricate, so extensive, so complicated, and important, at present; that I shall reserve for my amusement at a future period, and shall only, at this time, make a few obser-



uations on sensations, and then dismiss the subject.

30. The nerves distributed to the organs of sense are formed of the same materials as the other nerves; that is, they consist of fibres conveying the *æthereal* and other fibres transmitting the *phlogistic power*.

31. In the organs of sense these distinct fibres, I suppose, are exposed *together*, so as to be *each* and *singly*, subject to *impressions* from such substances or powers as are capable of acting upon them, through the *material coverings* with which they are always defended.

32. Whatever, then, is capable of acting upon either the *æthereal* or *phlogistic* nerve, so as to *excite* it, is capable of producing a *sensation* in the sensorium, by the transmission of that excitement by the nerve to the brain.

33. If the *æthereal power* of the nerve be



excited, it is natural to suppose that it will be perceived in the sensorium with a *different sensation* than if the *phlogistic* nerve were excited: and if *both* be excited at the same time, the sensation perceived in the sensorium must be still *different* from *either*.

34. But either of the powers we know are capable of *various degrees* of excitement; consequently, if *either* of them be *singly* excited, still the degree or kind of that excitement may be *various*, in different circumstances; and, consequently, will excite *various sensations* in the sensorium, or at least sensations *differing* in *degree* or *intensity*.

35. *Light* is the æthereal and phlogistic powers universally diffused, *excited* in a certain degree, which excitement is *rapidly propagated*: in that state, those powers are of *no colour*, that is, they simply excite the sensation of *light*, but *not* of *colour*.—If that excitement be propagated through the *atmosphere* surrounding a body, varying in *extent* and *degree* of excitement, in conse-



quence of the form of the body, and if *that* atmosphere has a peculiar attraction to *one* power, *that* power will be attracted towards the *surface* of the body, *particularly*; while the *other* is *not* attracted by the body or its atmosphere, and would proceed in a right line, were it not *drawn aside, in part*, by the *attracted power*.

The powers constituting the light are then *separated*; the æthereal power proceeds in *one* direction, the phlogiston in *another*; still, however, they are attractive to each other, and form a *coloured spectrum*, from which the æthereal and phlogistic powers are reflected to the eye, and produce the sensations of *various colours* flowing into each other.—The centre of this spectrum is *green*, and is evidently formed of the *two powers*, more or less perfectly excited and *connected*; while the *medium colour* of *one* end of the spectrum is *orange*, and of the *other* *purple*, or *indigo* as Sir Isaac Newton termed it.—The warm *orange*, glowing into *scarlet*, or attenuated into *yellow*, is still the *same power* more or



less perfectly *excited* and *freed* from the influence of the other power; and the cold *indigo*, or *purple*, deepens into *violet*, or brightens into *blue*, as the principle is more or less excited and disengaged, and is evidently excited by the *contrary power*, to *that* which excites the orange and warm colours.

36. All the sensations of *colour*, then, I suppose, are excited by the *æthereal* and *phlogistic powers*, in lucific excitement, being more or less perfectly *separated* and *modified* in their *excitements*, by the powers commonly excited and *arranged* around *material bodies*; in which states, passing to the expansions of the *optic nerves*, they excite the *æthereal* or *phlogistic fibres* of those nerves, or both, in correspondent degrees; which excitements being transmitted to the sensorium, are perceived as sensations of *colours*, varying with the excitement and the exciting cause.

37. In a similar manner, I conceive, all the sensations of the different organs of sense, ex-



citable by the *powers* of substances, are to be explained.

It is not simply the atmospheric *air* which excites the various modulations of *tone*, which enchant the soul with their melodious flow, or harmonious concord, by acting upon the *auditory nerves*, which, like all others, are both *æthereal* and *phlogistic*,—it is the *æthereal* and *phlogistic powers* in general diffusion around, which are capable of all the *various excitements* with respect to *tone*, that they are with respect to *colour*. The musical *scale* exactly corresponds with the *spectrum* of prismatic colours:—the three lower tones are excited by one power; the fourth, or middle tone, by the two powers; the three higher by the contrary power to the first: the different *velocities* of *vibration* in sonoric bodies, excite the *one* or the *other power*, or *both*, and excite them *also* in *different degrees*; and the sensations of harmony and discord in sounds, resemble the harmony or contrast of colours, in all respects, except in the actual sensations and the modes in which they are excited.



The nerves of *taste* and *smell* are each formed, also, of fibrillæ conveying the æthereal and phlogistic powers, distinctly; and the different sensations of taste and odour are produced by the æthereal or phlogistic powers, in different proportions and states of *evolution* in the various substances which are taken into the mouth or the nostrils, acting *together*, or *singly*, in *various states* of combination, separation, and excitement.

38. *All* the organs of *sense*, then, I suppose, are supplied with nerves, conveying the *æthereal* and *phlogistic powers*, but *singly*; and those nerves are subject to excitement from the æthereal and phlogistic powers singly, or separately excited in various degrees by different substances and means; *each* power producing a *distinct* sensation, correspondent to its state and degree of excitement.

The sense of *feeling*, however, may be an exception; as it seems to depend upon *material*



impressions, and not upon the *powers* excited by matter.

39. From what has already been advanced in explanation of the various functions of the living body, it appears to me evident, incontestably so, that there are *two powers* essentially necessary to produce those operations ; and that *each* power is conveyed by its *distinct nervous fibrillæ* :—it is likewise evident, that neither matter, nor the powers which actuate it, are *capable* of either sensation or thought ; consequently, there must be a *living principle* or *principles*, which can *feel* and *think*—which are *distinct* from both matter and power.

40. But we know that the *powers* in *motion*, can excite the principles of *life* or *animation*, as is evident in electricity : we know that the *powers* can excite *sensation*, as is evident when *light* excites the sensation of *colour* : and we also know that the principle of *life* or *animation*, can impart motion and excitement to *power*, as is evident when a *volition* in the brain causes a flow of the



*powers along a nerve to throw a distant muscle into action.*

41. Is it then *one* homogeneous, vital principle, which *animates* the *whole system*, or has *each power* its *specific principle* of life, or animation ?

42. Either of the powers or nerves may be excited to sensation, or to transmit its excitement to the sensorium ; but it depends upon the *state* of the *sensorium*, whether that excitement is *perceived* there or *not* : but, the nerve excited certainly does possess a living power ; so does the sensorium, and the one arises from the other.— It appears, then, that the excitement of the nerve, its power, and living principle, neither sleeping nor waking, is really *perceived* in the *sensorium*, unless the *sensorial principle* be directly *attentive* to that excitement ; and the sensorial principle *itself* is *without perception*, when *not excited* by the powers or principles of the nerves, or the ideas connected with or arising from them : consequently, it is allowable to suppose, that the



*intellectual operations* of the *sensorium*, depend upon *two principles*, which, acting together, produce *perception*, and which having the property of *resuming*, or *passing through* the various modes and states of action which they have been *accustomed to*, constitute, or produce those various intellectual operations, which we call *recollection*, *comparison*, *reason*, *judgment*, and *determination*.

43. If this be admitted, then, we may conclude, that *each kind* of nerve has its *distinct principle* of life, or animation : and by way of discrimination we may call the *principle* which actuates the nerves conveying the *æthereal power*, the *vital principle* ; and *that* which actuates the nerves transmitting the *phlogistic power*, the *animating principle*.

44. Either of these *principles* is capable of being excited by its respective power in motion, and of communicating that excitement to the *sensorium*, where sensation is *perceived* if the *contrary principle* of the *sensorium* be present to act



with it : and either of them may, by excitement in the sensorium, transmit its power to the muscles. But, *perception* and all the *consequent operations* of the sensorium, only arise when the *vital* and *animating principles* are excited to *act together*, and have supplies of the *æthereal* and *phlogistic powers*, upon which their excitement and power of action depend ; and as neither the *æthereal* nor *phlogistic power* can act alone, nor the *vital* nor *animating principles* can singly be excited to consciousness and thought, it is probable that the *medullary fibres* of the sensorium commune with their *powers* and *intellectual principles*, are so disposed and constructed that the *æthereal* origins of the *nerves* of sensation and motion with their *vital principle*, shall correspond to the *phlogistic medullary fibres* of the *sensorium* with their *animating principle* ; and that the *æthereal power* and *vital principle* of the *sensorium* shall correspond with the *phlogistic origins* of the *nerves* of sense and volition with their *animating principle* ; by which means, when either the sensorium or nerves are excited, the *contrary principle* at the point of contact, or where the *nerves originate*, is



*ready* to act and perceive, if the sensorium be in a state of excitement or *attention*, by the presence of the æthereal and phlogistic powers being excited to flow from their sources in the cerebrum and cerebellum, to the sensorium.

45. Perception and thought require the *co-action* of the vital and animating principles: their action requires *excitement* as well as powers; for excitement is only produced by the co-action of the *powers* with their respective *vital* or *animating principles*: when the intellectual operations are excited in any particular part of the sensorium, the *powers* of the sensorium are particularly directed to flow to *that excited part*; and when the intellectual principles are *destitute* of excitement, or *exhausted* of powers, they become *quiescent*: the powers are no longer excited to flow to the sensorium from their respective sources in the cerebrum and cerebellum, and *sleep*, or a suspension of the intellectual action, takes place.

46. Were these conjectures admitted, it



would follow, that perception and thinking, reasoning, judging, &c. resemble attraction; and the *principles* producing them have a similitude to the *powers* which produce attraction; for the *æthereal* power may be excited to *arrangement* around matter, and yet be *inactive*; so may the *phlogistic* power; and it is only when they come into *contact* in *similar states* of atmospheric excitement, that they *attract each other*, and draw their respective material centres into contact;—so also the *vital* and *animating principles* of the nerves and sensorium may either of them be excited, with its respective power, and yet neither of them, *singly*, can produce either sensation, thought, or consciousness; but, when they act *together*, that action is *perception, thought, or consciousness*, and the powers they are respectively connected with are brought into combination, and assume a new state, that of fire, or heat when diffused into the parts around; or those powers may be transmitted to muscular fibres, and cause them to contract before they combine and constitute heat by flowing into the



blood of the muscle which they have made to contract.

This is a subject, however, of too intricate a nature to be treated thus extemporaneously ; I, therefore, shall here close my investigations for the present, and terminate my inquiries with a few general observations on the effects of poisons, and on the influence of different metals when applied to the nerves of animals while they retain their living powers.



## SECTION XV.

*On the effects produced on living animals, by means of animal and vegetable poisons; and in consequence of cutting certain nerves connecting peculiar parts of the body with the brain.*

1. **I**T is not my intention to enter into a minute discussion of the numerous experiments with animal or vegetable poisons, which have been made by the Abbé Fontana, Dr. Monro, &c.; neither do I intend to consider all the experiments which have been published by Mr. Cruikshank and others, on the effects arising in consequence of cutting various nerves in the living animal; I mean only, to take a general view of the more important effects which have arisen from them, and to give such explanations as the principles of my theory offer, and leave it to others to judge how far those explanations are more or less satisfactory and consistent,



than the explanations which have hitherto been given, and commonly received.

2. As the Abbé Fontana has made the most numerous sacrifices of his feelings for the purpose of attaining knowledge, of any man with whom I am acquainted, I shall begin with his experiments first; not that I think the man who can look with an eye of indifference upon the agonizing tortures of animals, whose feelings are as acute as his own, is the more estimable on that account; but, because those modes of torture are more varied, and the effects the more numerous and diversified.

3. I by no means, however, think it blameable to try certain experiments, devised by cool deliberation, the results of which may be productive of general good; but, I must confess that *I think* thousands of the poor animals which were tormented and destroyed by the Abbé Fontana, were sacrificed in vain! Neither can I think it by any means justifiable, for a man to wantonly repeat the same cruelties again and



again, to satisfy the idle curiosity of men who are not *likely* to improve the art of removing the diseases of mankind, as is practised by some at present. In the hands of a Monro, of a Bailie, a Cruikshank, or any professor of anatomy, such experiments may be acts of mercy to the animal creation ; because, being dextrously performed before numbers, they may satisfy their curiosity, and afford them facts for reasoning upon, without every individual being left under the necessity of performing them to satisfy himself ; consequently, one experiment performed before hundreds, may prevent that experiment from being repeated hundreds of times ; that is, by each individual.

4. Can I read of a dog being confined without food for thirty days, merely to know how long that poor animal would be in starving to death—without horror?—Can I see, in idea, the cruel author of his unnecessary sufferings, approach him in his latter moments, and see him while he has any remaining strength, wag his tail, and look with affection and kindness



upon him, and yet leave him to his cruel fate without remorse?—I say, can I consider this, and not feel compassion, in its most poignant degree, for the harmless, suffering animal, and indignation for the author of his misery?—Surely I cannot, and I glory in my feelings!—But enough—it is not the *feelings* of mankind, but the EXPERIMENTS they have made which I have at present occasion to consider.

5. It is proved by the Abbé Fontana's experiments, that the poison of the viper mixed with the blood flowing *from* a vein, *prevents* it from *coagulating*; but, injected *into* a vein, the blood is *coagulated instantly*. This is a difficulty he could never surmount, because he resolutely denied every interference of the nerves in the effects produced by poison.

6. It is evident, however, that the coagulation *cannot* be simply effected by the *poison* acting on the *blood*, because by that simple action the blood is *deprived* of its *natural* power of coagulating: it must, therefore, to a certainty,



be produced by the co-operation of some *additional agent* ; and what additional agency it does arise from, may best be discovered by attending to the other effects produced, at the time when the coagulation of the blood takes place.

7. When the poison of the viper or the ticunas is injected into a vein, for example, the jugular, the actions of the heart and lungs are destroyed, so as to be *incapable of propelling the blood* ; and the right side of the heart and the lungs are found *distended with blood*, black, and coagulated.

8. The effect produced by the poison, then, is not simply the coagulation of the blood ; the *vascular extremities*, also, which have been exposed to that poison in the blood, have *lost their excitability* ; their *muscular action*, propelling the blood, is *destroyed* ; the *nerves* expanded upon the surfaces of those vascular extremities have *lost their vitality* ; they are no longer *excitable* by the powers in the blood, and no longer *capable* of transmitting their powers to the muscular



fibres in those vascular extremities, by which their blood is propelled.

9. The poison, then, when received into the blood, is circulated with it, and destroys the *vitality* of the *nerves* expanded on the surfaces of the *blood vessels*, particularly at their *extremities*, as it proceeds ; and as the nerves thus expanded on the surfaces of the blood vessels, constantly receive a flow of the *athereal* and *phlogistic powers* from the brain, which is accumulated in those expansions, and detained there by the vitality of the nerve, till they are excited to flow to the muscular fibres, it must follow, that when the poison destroys the vital power of those expansions, exposed to the influence of the blood, the *powers* accumulated *there* by the vital principle, must become *disengaged* by the destruction of that vitality, and *they must*, therefore, *flow* into the *blood*, ready to receive them. It is, therefore, by the accession of the *powers* of the *nerves* that the *blood* is *coagulated*, and the more completely the vitality of the nerve is



destroyed, the more sudden and perfect the coagulation of the blood.

10. When the poison of the viper, or ticunas, then, is thrown into the jugular vein, it instantly passes to the heart, and from thence to the lungs, where the *involuntary nerves*, expanded on the surfaces of the blood vessels, are exposed to the poisonous influence; the *vital principle* is *destroyed*; the nervous powers are no longer *detained* in the nerves; they *flow* into the poisoned *blood* and *coagulate* it; the vascular extremities are *no longer excited* to act; and the circulation of the blood ceases.

11. But this by no means accounts for the *immediate death* of an animal, in the manner effected by the injection of the poison; because, soon as the poison is injected, the animal becomes universally convulsed, and dies.

12. If an animal be prevented from breathing proper air, or air containing the æthereal acid, the blood accumulates in the right side of the



heart and in the lungs; the vascular extremities cease to act, and the blood ceases to flow;—but, before the animal arrives to this state, *violent efforts to inspire* are excited, by the powers constantly flowing to the nerves of the lungs; *accumulating* there for want of the excitement of the æthereal air; and *regurgitating* to the nerves and muscles of inspiration:—but, when poison circulates to the lungs, and destroys the vitality of the nerves there, there is *no* accumulation of powers in those nerves, and *no* transmission of those powers to the nerves and muscles of inspiration to excite them to act: consequently, the *poison* which *destroys* the *vitality* of the nervous expansions in the lungs, must, also, *destroy* the *vital principle* of the *nerve* in its *full extent*.

13. When, therefore, the poison is applied, to the nervous expansion in the lungs and heart, it *destroys* the *vitality* of the nerves in those parts; that destruction of the vital principle *ascends* upwards, towards the *brain*, by which the nerves of the lungs and heart are *incapacitated* from *receiving*



any *further* flow of the æthereal and phlogistic powers from the brain.

14. But, those branches of the *par vagum* which chiefly supply the lungs, and partly the heart, are derived from *all* the *nerves* of *motion*, arising from the brain ; and the powers flowing to *every* nerve from the brain, are *partly* sent to the nerves of the lungs and heart ; consequently, then, when the vital power of the nerves of the lungs is destroyed, as far as the *nerves* of *motion* from which they *arise*, the constant flow of powers from *those nerves* will be *prevented* from flowing to *the lungs*, and they will flow, therefore, in *unusual* quantities to the *muscles* in *general*, by which those muscles will be excited to *unusual action* : but, in a moment, the destruction of the vital principle of the nerves is communicated to *all those nerves* of motion, from which the nerves of the lungs arise, and also to the *brain* itself : the regular but increased flow of powers to those nerves quickly, therefore, becomes *interrupted* : they flow in *irregular jets*, producing convulsive motions in the muscles :—soon, however, the



poison destroys the vital principle of the *brain* and *nerves*, and *death ensues*.

15. If the poison of the viper, of the ticunas, of opium, or of the lauro-ceraffus, whose deleterious powers are the most evolved, be taken into the stomach, convulsions and death almost instantly ensue. This sudden destruction of the vital principle of the brain and nerves, *cannot* be owing to the *poison* acting upon the system by means of the *blood*; because, admitting that the poison is taken into the blood, in the stomach, it can only, instantly, destroy the vascular actions *there*, but *cannot* be *transmitted* to the *heart* and *lungs*, without *first* of all being collected in the *vena portæ*, and circulating through the *liver*; which requires a length of time, by *no means* compatible with the *sudden* destruction produced by the poison.

16. But, the stagnation of the blood in the stomach, *cannot* cause so sudden a destruction of the vital principle of the brain and nerves:—the poison, then, *must act* upon the *nerves* of the



*stomach*, by destroying the vitality ; and that *extinction* of the *vital principle* must *proceed* along the *nerves* towards the brain.

17. The *stomach* is chiefly supplied with nerves from the *par vagum* ; and those nerves like those of the lungs, arise from *all* the *nerves* of motion proceeding from the brain ; consequently, if the *vital principle* of the *nerves* of the *stomach* be destroyed by the poison, that deleterious influence will be communicated to *all* the *nerves* arising from the brain ; and till that destruction of the vitality of the nerves is actually *communicated* to the *rest* of the *nerves* and the brain, the constant flow of powers from those nerves into the *nerves* of the *stomach*, will be *gradually prevented*, as the destructive influence ascends ; and, consequently, *those powers* will flow in *increased* proportions to the *other nerves*, and produce those *convulsive* motions of the *muscles*, which so generally arise when poisons are applied to the *stomach*.

18. If a *large* proportion of poison, in a *very*



*active* state, be taken into the stomach, or thrown into the blood, instant death is produced, *without any convulsions, or muscular actions whatever*; consequently, the *vital principle* of the *nerves* may be *totally* extinguished, *without the powers in the nerve being in the least excited to flow.*

19. If, then, the poison of the viper be applied to the *trunk* of a nerve, the sciatic nerve, for example, so generally chosen for experiment by the Abbé Fontana, it may so *instantly* destroy the vitality of that nerve, as to *prevent* it from imparting *any motion* to its *powers*; consequently, as the coagulation of the blood is only effected when the *poison* and the *powers* of the nerves are *together* imparted to the blood, it was in vain for the Abbé to look for the *coagulation* in the *blood* of the muscles to which that nerve was distributed. The poison could merely act upon the *vital principle* of the nerve; that might be extinguished *without any flow* of the powers being excited; and, consequently, the blood could *not* be coagulated, because the coagulation de-



pend upon the *powers disengaged* from the *nerves* as well as upon the poison.

20. If the poison, then, be applied to the trunk of the sciatic nerve, and simply destroys its vitality, that destructive influence will be communicated to the brain ;—to *one single portion* of the brain, from which the sciatic nerve arises ; for the sciatic nerve is not like the par vagum which is connected with *all* the nerves arising from the brain ; it is simply a *nerve*, extending from the brain to the *muscles* :—the *small portion* of poisonous influence communicated to the nerve may destroy the vitality of *that nerve*, without being *sufficient* to derange, or destroy the vitality of the *brain* ; and, that that *is* the case, is evident, from those who having been bitten by a viper, have become *paralytic* with considerable *diminution* of the powers of the *brain*.

21. That poisons may act upon the nerves when applied to their *trunks*, is proved to a certainty, by the Abbé Fontana himself ; because, upon applying a spirituous solution of opium to



the crural nerves of frogs, the muscles in which those nerves terminated were deprived of motion : spirit of wine produced the same effect ; a solution of opium in water did not so evidently : —what then ? spirit of wine, at least, is capable of destroying the vital powers of the nerves ; and spirit of wine is a poison, whose general effects are similar to those of opium itself ; only, the deleterious powers are more evolved in *one* than in *the other*.

22. Since spirit of wine, then, is a poison which destroys animals when taken into the stomach, and when injected into the blood, as the poisons of the viper, the ticunas, the lauro-ceraffus, and opium do ; and since it evidently does destroy the vital principle of the *nerves* by application to them, instead of concluding, so directly contrary to experiments, that poisons are *innocent* when applied to the *nerves*, he ought to have concluded, that certain poisons, when mixed with the blood, or with the gastric fluids, may be capable of acting upon the nerves exposed to their conjoint influence, which poisons,



when their powers are *not evolved* by the blood or gastric fluids, may be *incapable* of acting upon a nerve itself; since other poisons, whose principles are in a *different* state of *evolution* and *activity*, do, *certainly*, destroy the vitality of the nerves to which they are applied.

23. But, that the poison of the viper may destroy the vitality of the nerves, for any thing which the Abbé Fontana has shown to the contrary, I have already explained: and that it *does*, in *some cases*, is evident from the paralysis which follows the bite of the viper, which, though sufficient to destroy the functions of a *voluntary nerve*, and even the neighbouring parts of the brain, to a certain degree, is *not* capable of destroying the *general vitality* of the system, when applied to the extremities of a *nerve of volition*.

24. An experiment made by Dr. Monro, relating to the present subject, I shall now introduce:—he found that when every communication between the trunk and posterior extremities of a frog were destroyed, except the *sciatic nerves*,



by injecting a strong solution of opium under the skin of the *posterior extremities*, they were deprived of sensibility and motion ; but, the *trunk* of the body was *not* affected.

In another experiment the Doctor found, that the solution of opium poured into the *heart*, produced convulsions of the *legs*, when the *venæ cavæ* and *aorta* were *previously cut* : and he also found that it affected the legs in the *same manner*, when poured into the cavity of the *abdomen*, *after* the heart was cut out.

25. From the first experiment it appears, that opium applied to the extremities of the *sciatic nerves*, deprives *them* of their powers of sense and motion ; but, that effect is *not* communicated to *other nerves* ; and from the other experiments it is evident, that opium applied to the *heart*, or cavity of the *abdomen*, *does* affect the nerves of *those* parts ; and from them the effect *is* also communicated to the *nerves* and muscles of the *posterior extremities*.



26. The sciatic nerves arise from the brain ;—  
 I do not, however, mean that they are directly *sent off* from the brain, but, that the fibres of which they are composed have *distinct origins* in the *brain*, although they pass along with other nerves in a mass which we call the spinal marrow : so that the spinal marrow is, in fact, no other than a *general assemblage* of the *nerves* distributed *from the brain* to various parts of the body, from which they are detached, in pairs, to the parts they are destined to influence. That this is the case, appears to me not to admit of a doubt ; for *volition* certainly arises *in* the brain, and it can transmit its power from the brain to *any particular* voluntary muscle, or even to a *certain part* of some muscles ; which proves that the *very fibres* of a nerve, distributed to *any particular* muscle, *originate* in the *brain*, which can excite its powers to flow to those fibres, and *those only* :—that this volition does reside *in* the *brain*, and that the excitement or powers which are transmitted to the muscle are sent *from* the brain, is evident from this consideration, that if the medulla spinalis be *cut*, *above* the part from



which *any nerve* is sent off, the volition may *still* remain, or be excited in the brain, but the intercourse being destroyed, it *cannot* throw the muscle, to which that nerve is distributed, into action.

27. The sciatic nerves, then, arise from the brain—from *one single portion* of the brain; and their office is to convey the powers excited by volition, from the brain to the lower extremities. If, then, opium be applied to those nerves, if it destroys their vital principle upon which the transmission of their powers depends, and if that extinction of the vital principle ascends to the brain, there it must stop: at least, any further effect must be small, as it cannot be supposed that the effect of the opium applied to so *distant* a part, and to a *single nerve*, can be communicated to the *brain*, with *sufficient power* to destroy *all* its *vitality*, as well as that of *all* the *other nerves*; because, the sciatic nerves, simply arise from *one portion* of the brain, and have *no* connexion with other nerves, except a few branches sent to the intercostals and par vagum, by which



they convey powers flowing from the brain; and even admitting that the extinction of the animating principle of the sciatic nerves, were to be communicated to those *involuntary* nerves, still, the effect could be but small; since *their* communications form but a *small portion* of those nerves, which are formed from *all* the nerves arising from the brain.

28. But, on the contrary, when the solution of opium is applied to the *heart*, or injected into the *cavity* of the *abdomen*, it acts upon the *extremities* of *all* the *nerves* of the intercostals and par vagum, distributed to those parts; and as those nerves are formed into various *plexuses*, the effect upon those branches distributed to *one part*, must be communicated to *all*: consequently, then, the deleterious effects of the opium on the heart or abdomen, will be communicated, not only to the intercostals and par vagum, but also to *all* the *nerves* of *motion* in the system, as *from them* they arise, and *with them* they are intimately connected. The extinction of the vital powers of the *involuntary* nerves, will be communicated



to *all the other nerves*, and from them to the *brain*; hence the *convulsions* and *destruction* of power and vitality, in consequence, if the quantity of opium applied be sufficiently great.

29. If this explanation be not just, there is no other means of solving the difficulty, but by allowing that there are *certain nerves* distributed to the lungs, heart, stomach, and abdominal viscera, along with the par vagum, which have the *singular property* of *conveying* the æthereal or phlogistic powers, in certain states, applied to their *extremities, directly to the brain*; while all the nerves of motion only convey the powers *from* the brain to the parts to which they are distributed.

30. That this may be the case, is by no means improbable; for we know that pure air will sometimes restore the functions of the brain and nerves, when they are suspended, and motion has ceased, by being applied to the nerves of the lungs; and that wine or spirits will impart instant vigour and energy to the brain and



nerves, when greatly exhausted, by being applied to the stomach, which must be effected either by the æthereal power in the lungs and the phlogistic power in the stomach, being *transmitted* by *certain nerves* to the brain; or otherwise, by the excitement which those powers give to the *vital* principles of *those nerves*, which *excitement* is communicated to the *brain*, as I have formerly supposed, rather than admit of a peculiarity in these nerves, which is not observed in any other; and I still must retain my former opinion, till it be found that this *peculiarity* in the nerves of the stomach, &c. *does*, in reality, exist.

31. I shall conclude this section with a few general observations and remarks on the experiments made by Mr. Cruikshank and others, on animals, by cutting the par vagum and intercostal nerves.

When the par vagum and intercostals are *both* cut, the animal is extremely affected; *respira-*



*tion* becomes painfully *laborious*; the lungs become *distended* with blood, and it dies.

In this experiment the animal lives *several hours*; but, if the spinal marrow be cut above the first vertebra of the neck, the animal dies *instantly*.

32. When the par vagum and intercostals are *all* cut, respiration becomes laborious; the actions of the stomach are disordered; the actions of the heart are impaired; the lungs become loaded with blood; and the animal dies:—because the functions of the lungs, of the heart, stomach, &c. depend upon a *constant flow* of the æthereal and phlogistic powers from the brain and nerves of motion, to the par vagum and intercostal nerves; which powers, flowing to the *expansions* of those *nerves* upon the *blood vessels*, are excited by the blood, when duly supplied with phlogistic food and æthereal air, to flow to the *muscular fibres* interwoven in the *vascular extremities* of those parts, and cause them to *contract*, by which contraction the *blood* is cir-



*culated* :—consequently, if the flow of those powers to the lungs, heart, stomach, &c. be *cut off*, their *vascular actions* must gradually *cease*; and the *blood* must be propelled with *diminished* power and motion, as those powers in the nerves become more and more exhausted.

33. That the actions of the heart, lungs, &c. do not immediately cease, when those nerves are cut, is owing to this cause, that, although the *par vagum* be cut, and the supposed origin of the *intercostals* also, still the *intercostals* are *largely* supplied with *powers* from *all* the *spinal nerves*; *those nerves* will *continue* to receive supplies from the brain, so long as its functions remain; and, consequently, they must impart a *portion* of *those powers* to the *ganglia* of the *intercostals*; which, flowing to the lungs, heart, &c. will keep up the vascular actions there for some time; but, as the *intercostals alone*, are *not* sufficient to keep up the natural actions of those parts, the functions must *gradually diminish* in energy; the lungs will become loaded with blood; and death must ensue.



34. When the nerves are cut, the *respirations* become laborious and unnatural, because the æthereal and phlogistic powers constantly flowing to the par vagum from the brain, or nerves of motion connected with them, *cannot*, then, *flow* to the lungs and discharge themselves in vascular actions; they, therefore, by means of the peculiar communication between the par vagum and the nerves which supply the diaphragm and other muscles of inspiration, *flow*, in a constant stream, to *those nerves and muscles of inspiration*, which are, therefore, *excited* to *full and frequent action*, till the *want* of circulation in the lungs *deprives* the brain of its regular supplies of æthereal air and phlogistic blood, when its functions cease.

35. That the actions of the lungs, heart, &c. do not *immediately* cease, when the par vagum and intercostals are cut, in the usual manner, is owing to the *powers* communicated to the intercostal nerves by the *spinal nerves*, is *evident*, from the *instant* death which follows the cutting of the *spinal marrow*, where it leaves the cranium; for



then the *spinal nerves themselves* have *no flow* of powers to communicate to the intercostals ; neither have the nerves of the lungs, heart, or muscles of inspiration *any supply* of powers ; in consequence of which, their *actions* must *instantly cease* ; the blood must stagnate ; and the brain being deprived of the excitement and powers imparted by the flowing blood must instantly lose its functions and its life.



## SECTION XVI.

*On animal electricity, or the excitement communicated to the nerves by the application of metallic substances, &c.*

1. **M**ANY have been the experiments on this subject, by Galvani, the first observer of the influence, by Valli, Monro, Volta, Fowler, Wells, &c. ; but as the effects proceed from the same principle, or cause, howsoever diversified the means of exciting them, I shall not enter into any minute detail of those experiments, but shall simply confine myself to such as are the most simple and constant ; and, therefore, the most satisfactory and the properest to reason from.

2. If a nerve be laid upon zinc, and the muscle in which that nerve terminates be con-



connected with the zinc, by a golden probe, the muscle will be agitated, as soon as the probe comes in contact with the zinc :—whether the nerve and muscle be separated from the body, or not, does not signify, if the vital principle still remains.

3. The nervous powers, then, are excited to flow along the nerves, and that too by the metals; because those powers were quiescent, and would have remained so, had not the metals been applied, or some equivalent, exciting cause.

4. If the nerve and its muscle be put into water, near to a piece of zinc in the same water, and the golden probe be introduced into the water, so soon as it touches the zinc the muscle is agitated.

5. It is evident, then, that water conducts this exciting power; consequently, it is also evident, that neither the nerve, the muscle, nor the metals, were in excitement *previous* to the appli-



cation of the gold probe; because, if they were, the water would have conveyed that excitement from the one to the other, as well *before* as *after* the junction of the gold and zinc: and it is clear, to a demonstration, that the exciting cause is *not* the *electric fluid*; because, if the zinc, or gold, had been electrified before, the instant they had *touched* the *water* their electricity would have been *discharged*, without a possibility of bringing the two metals in contact, in contrary states of electricity, in the water, which the conditions of the experiment require, since the zinc and the probe must come in *contact*, within the water, to produce the contraction of the muscle.

6. That the effect in question is *not* produced by electricity, then, is certain: in fact, no man can duly attend to the circumstances of the two, and admit even the possibility of their being the same principles, in similar states of excitement; though every one must see so striking a resemblance, in some respects, as to feel no difficulty in admitting, that they may be the *same* principles, in *different* states of excitement.



7. If zinc be applied to the nerve, it may be again withdrawn, without producing muscular agitation : if gold be applied to the muscle, it may again be taken away, without any apparent effect on the muscle ; neither of them, then, *singly*, excites the nerve or muscle, so as to produce agitation.

8. If the zinc be applied to the nerve, and the gold probe to the muscle, still there is no agitation of the muscle ;—but, apply the metals to each other, and the muscle is agitated :—by the contact of the metals, thus connected with the nerve and its muscle, then, the nerve is excited to agitate the muscular fibres in which it terminates.

9. But, nothing is communicated :—if the metals be connected with the nerve and muscle, by means of water, or any conductor of the electric fluids, or by a metallic chain, still the muscle is agitated when the metals come in contact, although no electric appearance can be perceived ; neither can the most sensible elec-



trometers discover the least appearance of electricity :—had the metals communicated a flow of any kind of fluid, similar to the electric fluid, it would have been discoverable ; but, no such thing can be perceived, neither is the state of the metals altered, with respect to electricity, by being in contact, from what they were before.

10. Besides, the nerve is a conductor of electricity ; if, then, the zinc were *electric* with one kind of electricity, and the gold with the contrary, so soon as they were applied to the nerve and the muscle, they would *discharge* themselves *along* the *nerve*, and agitate the muscle, which they do not ; unless the metals themselves be in contact.

11. We know, however, that when the metals are in contact, they cause the nerve to agitate the muscle, in the same manner as when the nerve is connected with the external coating, and the muscle with the inner surface of an electrified jar :—in the latter case, we know that the



nerve is excited by the contrary kinds of electric fluids rushing into combination, along the nerve, by which it becomes excited to agitate the muscle :—consequently, as the effect is the same, we must refer it to the same, or a similar cause.

12. Electricity, then, excites the nerve by the contrary electric powers, flowing in contrary directions, to combine with each other, along the nerves.—The excitement, by means of contrary metals, then, must be effected by the contrary powers, flowing in contrary directions, to combine along the nerves :—but, the metals had *no* such powers to communicate, as is evident from par. 9 and 10 :—the nerves themselves, therefore, possessed the powers, and the metals only *separated* and *excited* them, when *singly* applied ; but, when they were brought into contact, they *destroyed* or *counteracted* each other's power of exciting the powers of the nerve, and *left* those powers, thus separately excited in the nerve and the muscle, to *rush* along the nerve, into *combination* ; by which means, the *vital*



principle of the *nerve* was excited, to transmit its *powers* to the *muscular* fibres, and throw them into action.

13. We have already seen (sect. vi.) that it is an invariable law, that when the æthereal and phlogistic powers are made to change their state, it is by *separation*; and whatever *kind* of excitement is imparted to the *one* is, also, assumed by the *other*.

We also know that when any body is electrified with one kind of electricity, it will excite the common powers of any conducting body near it, to assume a contrary state, or to form an electric atmosphere of the contrary kind of electricity, not by communication, but simply by the attraction of the power forming the electric atmosphere, to the contrary power always present, in some state or other, in surrounding bodies; and we also know that when the conducting body, thus having its principles attracted and excited, is withdrawn from the influence of the electrified body, those principles will *return* to



their *former state*, by *diffusing* themselves equally over the conducting body; or, if the electrified body be discharged by the contrary electric fluid, the conducting body will *lose* its atmosphere *without* being *removed* from the electrified body, by the attraction *ceasing* which separated its powers and excited them.

14. It is evident, then, that the æthereal power when excited around one body, will attract the phlogistic power of another body within its influence, (13)—and it is equally evident, that when the phlogistic power is excited to any particular state, the æthereal power which was combined with it must be separated from it, and must assume a similar state.

15. These facts, then, afford an easy solution of the experiments in question.

Zinc has a natural attraction to *one* of the *powers*, in preference to the other; and gold has an attraction to the *contrary power*, which they



will, therefore, *peculiarly excite* at their surfaces.

Suppose that *zinc* attracts, or excites, peculiarly, the *æthereal* power, and *gold* the *phlogistic* power, naturally, and at all times, when circumstances do not forbid.

If *zinc* be applied to a *nerve*, its excited *æthereal* power will have an influence upon the *phlogistic* power of the *nerve*:—for that the nerves do convey and contain *both* the *æthereal* and *phlogistic* powers, at all times, during life, I have already, in many instances, attempted to prove:—this attraction of the *zinc*, however, *singly* exerted, is not sufficient to separate and excite *both* the powers of the nerve, completely; for to effect that purpose, *both* the powers must be *attracted*.—If, then, the *gold* probe be applied to the muscle, its *phlogiston* will attract the *æthereal* power of the *nerve*; and by the *conjoint* influence of the *zinc* upon the nerve, and the *gold* upon the muscle, or the extremities of the same nerve in the muscle, it must follow,



that the *powers* of the nerve will be *separated* and *excited*; the *phlogistic* power will be attracted towards the zinc, and the gold will attract the *æthereal* power, towards the muscle, and by that means, the *æthereal* power of the zinc, and the phlogiston of the gold, will become perfectly excited also.

16. If now the gold be applied to the zinc, the *æthereal* power of the zinc will, by contact, immediately attract the phlogistic power of the gold; in consequence of which, each will *lose* its attraction to its respective *power* of the *nerve*:—those powers will immediately rush in contrary directions, to *combine*, along the nerve; the phlogiston of the nerve attracted by the zinc will rush towards the muscle, and the *æthereal* power excited by the gold will flow from the nervous extremities in the muscle, to the trunk of the nerve itself; by which means, the *equilibrium* of the powers in the nerve will be *restored*;—but, by that rapid *motion* and combination, the *animating* principle of the nerve will be *excited*: the consequence of which is, a *flow* of



the *two powers*, by their respective nervous fibrillæ, to the *material* principles in *muscular* arrangement; which, by that means, are thrown into action.

17. Whether the excitement, therefore, begins at the muscle or the nerve, is the same in effect, as the two powers flow in *contrary* directions; and whether the zinc be applied to the nerve or to the muscle, is of no consequence, as the influence is still upon the nerve in both places, and *both* the powers are there.

18. If water be interposed between the zinc and nerve, or the gold and muscle, still the effect is produced; because every conductor of electric excitement is a conductor of *this*; the chief difference consisting in this, that in the electric excitement each power excites a *secondary*, or *external* atmosphere of wide extent, but in this state, the metals give a *simple excitement* to one principle in preference to the other, which is *not diffusible* or *separable* from the *metal itself*; neither is it so excited as to be capable of



acquiring a *secondary* atmosphere, at least so sensibly as to be evident to us.

19. It may be objected, that if the excited power of the metal is not diffusible, how then does it excite the nerve, when water is interposed, or other conductors, to such an extent as the metallic atmosphere cannot be supposed to equal?

The manner in which its influence is communicated is easy to explain; the zinc, we will again suppose, excites the æthereal power; every particle of water, like all other bodies in their common state, is attended by the two powers universally diffused.

If a conductor be charged with the electric fluid A, and a conducting body with its natural powers in an unexcited state be brought near it, the powers of that body will be attracted, separated, and excited;—the *approaching side* will have a part of its common principles in the electric state B, and the *distant side*



of the same body will have the other portion of those powers in the electric state A;—that body would then influence another, and so on, to any extent, if near enough to receive the progressive influence; and *that side* of every particle *most distant* from the charged conductor, would *always* have its principle in the *same* electric state A, as the conductor itself:—consequently, the *æthereal* power of the zinc, by influencing the powers in the water, will always attract the phlogistic powers of the particles of the water, *towards itself*, and the water will, therefore, act by this *æthereal* power upon the *nerve* opposed to the *contrary* or *distant* sides of its particles.

20. As the powers excited by the metals in their common state, are but *slightly* excited, any peculiar alteration, or change in their surfaces, may produce a change in their excitements; and different parts of the same metal may be so altered, by any local change of its surface, as to acquire a new power of excitement: and when the powers in the nerve are abundant, or the nerve is irritated by certain acrid applications,



its vital principle may be excited to transmit its powers by the slightest influence; and as the blood is always necessary to enable the nerves to produce muscular contraction, when it is nearly exhausted of its æthereal power, and the contractions cease, they may be again restored, or they may be again augmented, by applying such fluids, to the muscles, as contain the æthereal principle, such as the oxygenated muriatic acid.

21. That a metal may be changed in its peculiar attraction to one or other of the powers by friction with, or application to, certain other matters, is evident from experiment, and also from analogy; for most, if not all electrics *per se*, may be made to excite *either* the æthereal or phlogistic electricity, by means of *different rubbers*; consequently, there is no difficulty in admitting that a metallic probe, or rod, which naturally is peculiarly attractive to the æthereal power, may be either wholly or partially changed, by the action of other substances, so as to have a preference for the phlogistic power,



22. This being the case, a single metal rod may become both exciter and conductor.—For example, if a probe of zinc be rubbed by another substance of a different kind, for half its length, it may then have an excited phlogiston on one half, and an excited æthereal power on the other half.—If the æthereal end be applied to a nerve, that æthereal power will slightly attract and excite the *phlogistic* power of the *nerve*, while the æthereal power of the nerve will be slightly excited also, and recede towards the muscle: the excitation, however, is but *slight*, and the separation *imperfect*; because the æthereal power of the nerve is not *equally attracted* with the phlogiston:—but, if the other, or phlogistic end of the probe be now applied to the muscle, it will attract that æthereal power of the nerve in the muscle:—the powers of the nerve, then, will be completely *separated* and *excited*, and they, in return, will impart a *complete excitement* to the powers of the probe:—but, at the instant that the æthereal and phlogistic powers of the probe receive this active excitement, they *attract each other*, and counter-



act each other's excitement; and, consequently, leave the *powers* of the *nerve* and *muscle* to rush together along the nerve, into their usual state; by which *commotion*, the *vital* principle of the nerve is *excited* to transmit those powers to the *muscular* fibres, and cause them to *contract*.

23. All that is requisite, then, to this mode of exciting the nerves, while they retain their powers and vital principle, and the blood in the muscles is not exhausted of its powers, is, the application of two substances, or surfaces, one having a peculiar affinity to the *æthereal*, the other to the *phlogistic* power;—one must be applied to a nerve, the other to the muscle in which that nerve terminates, or to a different part of the same nerve itself:—they must be applied to those different parts immediately, or with the interposition of some perfect conductor of both powers.—Thus applied, the *one* will have a peculiar influence upon the *æthereal* power of the *nerve*, the other upon the *phlogistic* power; by this mutual and double influence, the powers of the nerve will be *separated* and instantly ex-



cited; by that means, *each* power will instantly exert its full influence upon the *contrary* power in the substance applied; and will, therefore, excite *it* to a state of *perfect* excitement equal to its own.—In this state, when the power of the nerve has fully excited the power of the substance applied to it, and the power of the muscle has equally excited the power of the substance applied to it, if those *two substances* be brought into *contact*, the excited phlogiston of the *one* will then instantly *attract*, and *combine* with the excited æther of the *other*; by that means, their attraction to the separated powers of the *nerve* will *cease*; and *those powers* will rush into *combination*, and excite the *vitality* of the nerve, to produce *muscular* contraction, as before observed.

If the powers of the nerve be abundant, and the exciting substances be then *separated*, at the *instant* of separation, the contrary powers of the substances will again, suddenly, attract the *powers* of the nerves to their *extremities*; and by that sudden *flow* of the *powers* of the



nerves in *contrary directions*, the *vitality* of the nerve will *again* be *excited* to throw the muscles into action ; as is frequently observed, in trying the experiments.

24. Water, it is well known, readily transmits the influence of the powers of the metals and nerves to each other, so as to enable them to excite and attract each other ; but water, as perfectly as it conducts those influences, does not excite either the nerves or the metals ; water will conduct the influence from the nerves to the metals, when excited, but it cannot excite the nerves, because it indifferently contains *both* the æthereal and phlogistic powers, and is *equally attractive* to *each* ; but to excite and separate the powers of the nerves, it requires *two surfaces*, *one peculiarly* attractive to *one* power, and the *other* to the *other*.

25. Water cannot excite the powers of the nerves and separate them, because it is equally attractive to each power, and particularly so to



neither; but two metals may, if one be peculiarly attractive to one power, and the other to the contrary; because, being applied to distant parts of the nerve, they will *draw* and *excite* its *two powers* at those *distant parts* of the nerve, from which they *cannot* return to *combination*, unless the *metals* be *taken away*, or the attractive powers of those metals be removed from the separate powers of the nerve, by *attracting each other*. — Water may convey the influence of the separate powers of the metals to the nerves, by which the powers of the nerves may be separated, because those powers of the *nerves* are *moveable*; but water cannot convey the *power* of *one metal* to the *other*, because *those powers* are peculiarly attracted, excited, and *detained*, by the principles of the *metals themselves*; in the same manner as the *magnetic* atmosphere is inseparable from iron, and not conveyed by water, which water still readily conveys the contrary atmospheres of those powers in an *electric state*.

26. The nerves, then, contain the æthereal



and phlogistic powers: when two surfaces are applied to distant portions of a nerve, *one* of which surfaces is capable of attracting the *æthereal*, the *other* the *phlogistic power*, in particular, the two powers of the nerve are separated and excited, and in those states of separation and excitation, communicate in return, a *higher degree* of *excitement* to the powers of the different *surfaces* by which they were separated; in consequence of which, the *æthereal* power of the *nerve* is *fixed* by attraction to *one* exciting surface, the *phlogistic* power to the *other*.

In this state, if the contrary exciting surfaces be brought into contact, their *respective powers*, thus excited, will immediately *attract* each other; and by that means the powers of the *nerve* being no longer *detained* by those surfaces, will rush into *combination*, along the nerve; by which rapid *motion* the *vital* principle of the nerve will be *excited* to transmit its powers to the *muscular* fibres, and thus produce the *muscular agitations*, which are the subject of investigation.



27. The phenomena of animal electricity, as it is called, then, are produced by the same æthereal and phlogistic powers as constitute electric atmospheres; only they are in *different states of excitement*, and not formed into atmospheres attracting *secondary* atmospheres around them, as is the case when they are excited to become electric.

The nerves, we have formerly observed, do not convey or contain the powers in an *atmospheric state*; and the metals which are employed as excitors, peculiarly attract their respective powers, from which they are *not separable*, and which they do *not excite* to the *atmospheric* state; in consequence of which, they are peculiarly adapted to act upon the powers in the nerves, by a simple and mutual communication of influence, as being in nearly similar states of simple excitation: and the contraction of muscular fibres by common electricity, and by this metallic excitement, differ in this respect, that in electricity the contrary electric fluids are *communicated* to distant parts of the nerve, and rush in contrary direc-



tions to combine along the nerve, while in this metallic influence, the *powers* of the *nerve itself*, which were *separated*, by contrary attractions to *distant parts*, rush into *contact*, by becoming *disengaged*, in consequence of the contrary powers which attracted and separated them, withdrawing their attractive influence from the powers of the nerves to attract each other, when immediately in contact : so that electricity excites the vital principle of the nerves, by the rapid flow of the *foreign* electric powers ; but in this metallic excitement, the vital principle is excited by the rapid flow of the *powers* of the *nerves themselves*, to regain the *equilibrium* which was *destroyed* by the metallic influence. In both cases the *motion* of the powers excites the *vital principle* of the nerves to transmit the æthereal and phlogistic powers, by their respective nervous fibrillæ, to the material particles in muscular arrangement ; where, by exciting the powers in the blood, those particles are attracted towards each other ; the muscular fibres they form are shortened ; and the two powers combining at the instant of their



discharge into the blood, form fire, which diffusing itself in the blood, constitutes the *heat* which is constantly generated by muscular action during life.

28. The reason why neither mechanical stimuli, nor the metallic exciters, produce motions of the *involuntary* muscles, by being applied to the involuntary nerves, may be easily seen, by only considering that the nerves which are distributed to the parts whose actions are *involuntary*, are *expanded* upon the *surfaces* of the extremities of the *blood vessels*, in the state of reticulated, or medullary *plexuses*; and that it is from *those plexuses* that the nervous fibres are sent to the *muscular fibres*; consequently, an excitement given to an involuntary nerve, can proceed *no further* than this *peculiar expansion*; and to produce the *action* of those involuntary muscles, the powers in these *nervous expansions*, *themselves*, must be *excited*, before they can be made to flow to their respective muscular fibres, and cause them to contract.



Having thus passed through the subjects I had proposed to myself for investigation, but in a much more slight and extemporaneous manner than I at first intended, I shall now lay down my pen for the present.—I have attained my object in writing, in the amusement which the investigation of my subject has afforded me, and I offer the ideas which have occurred, to those who may be disposed to attend to them.

FINIS.



It is the first time that I have  
proposed to you a subject of this  
much more than I have proposed before  
than I at first intended. I have  
now put the subject before you  
and I am sure that you will find it  
very interesting and I am sure  
I shall be able to give you  
a very full and complete answer.



