Observations on the animal œconomy.

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OBSERVATIONS

ON THE

ANIMAL ŒCONOMY.

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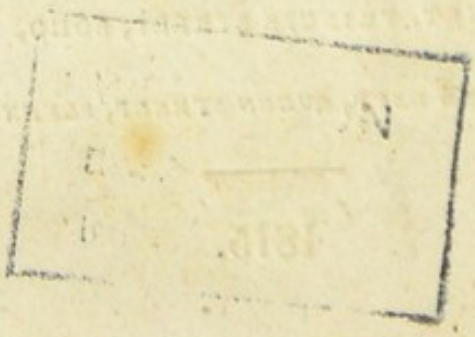

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THE purpose of the following pages is to give a general view of the functions of the Animal Œconomy; or, more properly, perhaps, of the principal opinions which have been entertained respecting them. No new theories are brought forward; and if there is any originality in the work, it consists in the manner of considering the opinions of others.

It may, perhaps, be proper to state, that the first part was written before the appearance of a Treatise by a distinguished Member of the Medical Profession, on a similar subject, but in which a totally opposite view of the matter is taken.

THEORIES

OF

NERVOUS ACTION.*

IT is generally admitted that the nervous system is, if not that part of the body which may be considered as the immediate instrument of sensation, at least, somehow or other, essentially necessary to this function; with respect to voluntary motion, nearly the same may be said. It appears most probable that nervous influence is also a sine quâ non to all thê functions of the system. This, however, has been questioned, and an opinion totally opposite has, on this last point, been maintained of late by many physiologists; that the nervous system is only an appendage, and that the actions of it tend to prevent the operations of, and to abridge the duration of life.

* To obviate any objection as to the propriety of the term action, it may be necessary to state, that by it is only meant that condition or state of the nerves on which their functions depend.

The mode in which the brain and nerves perform their functions, is however totally unknown, and the vital principle, whether immediately connected with the state of these organs, or independent of them, is equally so. It has been asserted, that until the principle of life is detected, no improvements can accrue to medical science, except from experience;* but this is evidently founded on fallacy. If the laws according to which this principle acts, were completely investigated, it would be sufficient to lead to many reductions, theoretical and practical, independent of what is commonly called *experience.* A discovery in physiology, of equal importance with that of Sir Isaac Newton, in general physics, would consist only of the developement of some general fact in the living body, to which a great variety of the phœnomena might be referred; and it would not be necessary that the *cause* should be discovered, in order to establish a complete analogy in the two cases. Newton did not discover the cause of gravitation; he only ascertained, that it acted according to a certain law. The more complicated nature indeed of the living body, presents difficulties in this investigation, which do not occur in dead matter; it is not certain (and the contrary is probably the case) that any single principle in the animal œconomy, exists of equally extensive application with the law of gravitation, in inanimate nature; yet this consideration is totally independent of the cause producing the

* Vide Heberden Comment. sub Finem.

phœnomena in question, which is equally unknown in both cases.

The hypotheses which have been invented to explain the phœnomena of nervous influence, and which have by many, especially among the older writers, been also applied to the vital principle itself, may be referred to two heads; those which are founded on the supposition of a very subtile species of matter, of some kind, existing in the brain and nerves, under the denominations of animal spirits, nervous fluid, &c. which has been considered by different authors, as of different nature. The oldest opinion seems to have been, that it was of an aerial nature; by others it has been compared to light — to the electric fluid — to fire.

Secondly. Vibrations have been conceived to take place in the substance of the brain and nerves; this hypothesis is of later invention than the former. It appears, however, to be liable to all the objections which are applicable to this, besides additional ones.

Vibrations, which ought to extend through the whole length of the nerves, and to continue as long as sensation, could only take place in bodies extremely elastic, and by no means in a substance so soft and pulpy, as that which composes the brain and nerves. It is hardly possible to imagine any species of matter, less adapted for a vibratory motion, than this medullary substance, which recedes on the slighest touch, and retains any form which is given to it by external pressure. The extremities of nerves, in which the sensibility is greatest, are the most pulpy, and of course less

susceptible of a vibratory motion, than even the other parts of the same system. The vibrations must be most considerable in those cases, where the substance of the brain and nerves is most firm, and of course sensibility and irritability must also be in the same proportion increased; therefore sensibility and irritability ought to be greatest in old age, least of all in infancy, less in the female than the male sex, and universally these would exist in greatest degree, as the rigidity of the simple solid was greater—directly contrary to well known facts.

The greater number of nerves have ganglions and plexuses interspersed throughout their course, both of these must interrupt the vibrations; the first, by opposing an obstacle of a firmer consistence than the nerves themselves; the latter, by dissipating the oscillatory movements among a multitude of smaller ramifications of the nerves. The nerves are not sufficiently fixed at their extremities, to afford a point of support.

The difficulty of conceiving vibrations in the substance of the nerves themselves, has led many enquirers to the belief, that these take place in a fluid contained in the nerves. This theory was adopted by Haller, whose reasoning on the subject, however, seems founded on very loose analogies. "Et motum ad cerebrum venire credas, cum "a fragore metallorum pulvere pyrio oneratorum "commotiones in cerebro adeo manifestæ & vio-"lentæ succedant: earum similes, quæ ab ictu "aliquo capiti ipsi inflicto, sequuntur. Iterum idem "confirmatur exemplo simillimæ scintillæ, & a sili-"cis & chalybis vero conflictu, & alterius imagi-

"nariæ scintillæ, tum a frictione oculi natæ, tum "absque oculi vitio, in epilepsia, & convulsivis "malis. Motus ubique solus est, qui & in cerebro "mentem, & in objecti externi sensatione nervum "sentientem adficit. Is motus possit ad cerebrum "venire per vibrationes solidarum fibrillarum nervi "optici: potest etiam per fluidi, iis nervis con-"tenti, motum pernicem, qualem alibi ostendimus. "Sed vibratilem naturam a nervis ostendimus alie-"nam esse: sensuum ergo impressiones per ele-"mentum fluidum adveniunt ad eam sedem, qua "menti repræsententur. Ea est in cerebri, & cere-"belli medulla."—*El. Physiologiæ*, tom. v. p. 530.

The ancients contended for the existence of three sorts of spirits; the animal spirits, which gave rise to the voluntary motions, were formed in the ventricles of the brain; the vital spirits, which presided over the motions of respiration, and the pulsations of the arteries, were derived from the lungs and heart; lastly, the natural spirits, to which nutrition, growth, and generation were owing, were elaborated in the liver. Here we see the origin of the division of the functions of the living system into animal, vital, and natural, which has continued to the present time. Some modern philosophers have imagined that there were two sorts of spirits; one distinct for voluntary motion, which originated from the cerebrum; the other for the performance of the vital actions, from the cerebellum.

A distinction has also been made between the spirits which were concerned in sensation, and those which contributed to motion; some have imagined that the nerves of sensation and motion,

were distinct from each other, or, at least, that they were different fibrillæ of the same nervous trunk.

The precise nature of the office of the nervous fluid, has been also a subject concerning which a great diversity of opinion has prevailed; in general it has been considered as the principle of life, or, at least, as the cause of sensation and motion. Some, however, have conceived that it only served to keep the nerves in a proper state for the performance of their functions.

A circulatory motion has been ascribed to it; but although a circulatory motion, or, at least, some sort of movement, was admitted in this fluid by the ancients, it does not appear that they had any idea of vibrations taking place in it. They seem to have conceived it be of an aqueous, mucilaginous, and incompressible nature. It was only after the invention of the hypothesis of vibrations in the substance of the nerves, and when it was perceived that the structure of these organs was incompatible with this supposition, that the vibratory motions were transferred to the nervous fluid.

Another question has been, whether the nervous fluid was conducted along the nerves, in a manner somewhat analogous to that in which electricity passes along, conducting substances; or whether the fibrillæ of the nerves, tubes in which it is contained, and in which it moves with an inconceivable rapidity, exceeding most other motions in nature,* according to some physiologists.

* Haller ascribes to the nervous fluid, a swiftness to enable it to run over nine thousand feet in a second: Sauvages calculates its velocity at thirty-two thousand four hundred feet, in the same

To both these suppositions may be opposed, the apparent incompatibility of the extreme mobility, tenuity and subtility, ascribed to the nervous fluid, with the confinement of it to the substance of the nerves. With the above mentioned properties, it is difficult to imagine that it could be confined within cavities, formed by these organs; still more so, how it could be conducted along them. It is here necessary to attribute either to the nervous fluid, or to the nerves themselves, powers different from those of any other species of matter; and then why not as well ascribe to them at once the properties which the hypothesis is intended to explain, without having recourse to any intermediate agent. Sensibility and irritability, are not more different from the qualities usually appearing in matter, than the power of counteracting or annihilating volatility or mobility, in such a manner as is here supposed; and at the same time admitting of the agency of these properties in another point of view. This argument has been stated with so much force and precision, by a late distinguished author, that I am induced to give it in his own words. "La coercibilité est "elle compatible avec la mobilité, la tenuité qu'on "leur suppose? Si c'est par leurs propres forces "qu'ils sont fixes dans les nerfs, il faut donc alors re- "connoitre, dans ce fluide, des forces, speciales, des "forces qui le distinguent de toute autre matière. "Dira-t-on que ce fluide tendant par sa nature, à

space. A writer, cited by Wilkinson (Elements of Galvanism,) estimates its velocity at an hundred thousand miles in the above space of a second of time.

" s'échapper de la cavité des nerfs, est retenu par les " force de leurs parois? Les membranes des nerfs " ont donc une force tres-active, independante du " fluide nerveux: et pourquoi n'en serait-il par ainsi " de toutes les parties du corps vivant? Pourquoi ne " pas accorder tout d'un coup la faculté de sentir et " de se mouvoir aux organes matérials dont l'animal " est composé? La sensibilite et la mobilité sont- " elles plus difficiles á concilier avec la connoissance " qu'on croit avoir de la matière, que cette force " étonnante qui anneanterait l'essence de la fluidité, " de la volatilité et qui s'opposeroit constammement " aux effets que ces qualités doivent naturellement " produire."—*Dumas*, tom. ii. p. 344.

The nervous fluid is supposed to be the same in all parts of the system, yet the effects which result from its agency are totally different in different organs; in the eye it only receives impressions from light, in the ear from sounds; with respect to irritability, the same difficulty occurs. Almost every part has its specific stimulus, which is necessary to excite it into action. The only difference that can be conceived, is the greater or less rapidity or force of its motions, which is a difference in degree only.

In the case of sensation, what is there in common with the motion of an invisible fluid? With respect to the voluntary actions, it is as easy to conceive that the mind produces motion immediately in the substance of the nerves, or muscles, as by the intervention of this fluid. When motion is once excited in the nervous fluid, it is difficult, or impossible, to imagine that it should be sufficient to give any mechanical impulse to the muscular fibres, or the fila-

ments of the nerves; for with the extreme tenuity which it is supposed to be endued with, although its velocity was greater than that of light, its momentum would be insufficient to produce any sensible effect. How then does it act? If it be said that it merely excites the muscular fibres to contraction, it is no longer the proper efficient cause of the animal motions; but only an exciting cause, like any external stimulus, and the real cause, by which the muscular fibres are capable of original motion, remains to be ascertained.

The nervous fluid has been stated by some, to be the connecting medium between the mind and body; but it is itself supposed to be material, and therefore the same difficulty, as to the manner in which it is acted on by, and itself acts upon the soul occurs, as with respect to the grosser matter of which the body is composed. Those who maintain this opinion, seem (although they may profess the contrary) to be, in fact, materialists; at least, to believe the soul to be only a finer species of matter, between which and the solid substance of the body, this fluid may be a sort of intermediate nature. But if there is any reason at all for concluding that the principle of sensation and intellect is different from matter, the same will go to prove that they are of a nature so totally distinct, as to have no property in common, and hence the idea of an intermediate agent, of course, falls to the ground. On the other hand, if what are called the mental functions, are considered as merely modifications of matter, it is surely more philosophical to attribute them to the organised parts, which compose the animal system,

than to an inorganic mass, however attenuated or subtile it may be.*

A ligature on a nerve does not produce any obvious tumefaction, yet this must have been the case, if it was a tube containing a fluid; particularly if it is considered that this fluid, moving with extreme trepidity, an accumulation of it to a considerable extent might be supposed to be produced in a short time, if the current was intercepted.

The nerves appear to act, in some instances, independently of the brain; after the nerve going to a muscle is divided, an irritation on the nerve, will occasion contraction in the muscle. This fact, which it is difficult to reconcile with any of the theories of nervous agency, is particularly unfavourable to the present. After the division of a nerve, it is needless to say, the part below the division could receive no more fluid from the brain; and with the velocity which the fluid is supposed to move with, that existing in it before the division was made, could not be still contained in it.

If the fibrilla of the nerves are tubes, in which a fluid is contained, the cavity of the tube must be so extremely small, as to increase the friction of the fluid against its sides, so as to give very great impediment to its motions; for the surface of the tube must be greater in proportion to its capacity, the smaller the cavity is: or it may be stated thus—the resistance which a fluid will meet with, in

* It is not meant by any thing here said, either to assert or deny the truth of the hypothesis of the materialists.

passing through the tube, will be in proportion to the extent of the surface which it comes in contact with, and this will be greater, compared with the quantity of the fluid, as the tube is smaller; when the tube is of so very minute a dimension, as in the present case, the resistance must be increased in an immense degree.

The impulses on the organs of sense, and the sensations which ensue, are apparently isochronous; no perceptible interval is interposed between them. In like manner, that act or state of mind called volition, and the motions of the voluntary muscles, take place so closely, that it is impossible to distinguish any, the smallest space of time intervening. This seems incompatible with any intermediate process, as that of motion from the organ to the brain, or in the opposite direction, or perhaps in both in succession. If the difficulty is evaded, by attributing to the motions of the nervous fluid a degree of rapidity, so great as to elude all perception, the possibility of this being the fact, may perhaps be admitted. But, where will be the end of making gratuitous suppositions, or what hypothesis is there, which might not be defended, if the possibility of what may exist, should be considered as sufficient ground for admitting it as a truth?

If those functions which are more purely mental, memory, imagination, &c. depend on certain motions in a fluid contained in the nerves, or the common origin of these (and it is hardly possible to avoid ascribing them to a cause of the same kind as the external senses, so far as they are connected with any organic affection) another

difficulty occurs, as to the cause exciting these motions, when all external impulse is out of the question. When we behold an object that is present, the rays of light falling on the retina, and collected to a focus, excites certain motions in the fluid contained in the optic nerve, which is thus communicated to the brain, and sensation and perception ensue, according to the theory in question; but when an idea of the object, when not present, occurs to the mind, by what means is any motion, produced in the brain or nerves, or any fluid contained in them? The suggestions of the memory or imagination are often taken for realities, as in dreaming or delirium, and they often produce the same effects on the system, as the original preceptions; thus the mere recollection of an object that has occasioned terror, may produce paleness, trembling, &c. in irritable habits. The state of the organ, therefore, connected with sensation and with memory, or imagination, must be supposed to be analogous; if in the one case, the motion of an invisible fluid is conceived, the same must also occur in the other, although, perhaps, in less degree; yet, how this motion should be produced at all, in the latter instance, seems inexplicable. A similar objection seems to apply to Dr. Darwin's hyphothesis, that ideas are merely repetitions of motions of the organs of sense.

The remark of Diderot may here be applied, "Pour ébranler une hypothése, il ne faut quel-"quefois que la pousser aussi loin qu'elle peut "aller."

It is a law in the animal œconomy, that a part that has often been excited to action, acquires a greater proneness and facility with respect to it. But motions in inanimate matter, that have once ceased, are not more easily produced in future; if again, the parts of the animal body are not mere inert matter, independent of the motions of the nervous fluid, the cause of life, sensation and motion, still remains to be discovered, and the nervous fluid, and its different modifications, are not this cause, contrary to the hypothesis. When an organ is in action, and at the same time sensations are felt in it, how do the two motions, in opposite directions (from the origin of the nerves to their extremities, and the contrary) take place at the same time, without counteracting or destroying each other?

If sensibility and irritability are both dependent on the nervous fluid, it is difficult to explain the circumstance, that those parts which are most irritable, have often least sensibility, and vice versà.

Many physiologists suppose the nervous fluid to be secreted in the brain, and that the nerves are excretory ducts, which carry it away when formed. This hypothesis seems, at first sight, to receive some confirmation from the necessity of a copious supply of blood to this organ, for the performance of its functions; in this respect, the brain having an analogy to those organs which are known to be glandular: but an objection occurs as to the taking place of this secretion, at the first origin of the embryo. This secretion could not take place without blood being sent to the brain; on the other hand, without nervous influence, which, ex hypo-

thesi, depends on the fluid formed in the brain, the circulation could not commence. In cases of asphyxia, where the functions of the brain, and the circulation are both entirely suspended, the same difficulty occurs; it does not appear in what manner, according to the theory in question, such a state could ever be recovered from.

Dr. Darwin says, *Zoonom.* sect. ii. 2, "The "similarity of the structure of the brain, to that "of the pancreas, and some other glands of the "body, has led enquirers into this subject to be- "lieve that a fluid, much more subtile than the "electric fluid, is separated from the blood by that "organ, for the purposes of sensation and motion. "When we recollect that the electric fluid itself, is "actually accumulated, and given out voluntarily "by the torpedo and gymnotus electricus; that an "electric shock, will frequently stimulate into "action a paralytic limb; and lastly, that it needs "no perceptible tubes to convey it—this opinion "seems not to be without probability, and the "singular figure of the brain and nervous system, "seems well adapted to distribute it over every "part of the body."

The minute structure of the brain does not seem sufficiently ascertained by anatomists; it is well known, however, to consist of two distinct substances, the cortical and medullary: nothing analogous to this occurs in the pancreas, or any other gland in the body. If a fluid, similar to electricity, is any how formed in the brain, (which is of itself sufficiently incredible) the term *secretion* would be improper, as it must necessarily be a process

totally different from that by which the bile, or any other secreted fluids, are separated from the mass of blood. The electric fluid exists, in fact, in the animal body; but in the other organs, as well as the nerves, it is impossible that it should be confined in those, as they are surrounded by conductors of electricity: as to electricity acting as a stimulus, it is no more than is true with respect to many other substances, which might, therefore, on the same ground, be considered as the cause of sensation or motion.

If, as some physicians, with apparent probability, have supposed, the brain and nerves are, in point of time and importance, the primary organs, the impossibility of secretion, being the mode by which the former of these parts performs its functions, is sufficiently evident; the supposition most consistent with this is, that the circulatory system is the first that is developed, or that begins its functions; and this is totally contrary to facts.

In cases where the brain is deficient of its usual supply of blood, the cessation of its functions takes place too rapidly, to admit of the idea of the secretion of a fluid being the purpose which is answered by it. When this circumstance takes place from any cause, as the abstraction of a quantity of blood from the vascular system, syncope ensues immediately; yet, it can hardly be supposed that all the secreted fluid which existed in the brain, before the abstraction of blood, can have been dissipated instantaneously.

It has been stated by some, "that the brain may "do the office of a gland, to furnish a fluid for

" its growth and nourishment, and for moistening " the contents of the encephalon; without admit- " ting the idea, that animal spirits are separated " from the blood, and circulated through the brain, " for the purposes of motion, sensation, and life"— " this would be," as the author observes, " *a secre- " tion of the living principle itself, which is an " absurdity:* the nerves originating from the brain, " cerebellum, and spinal marrow, are the medium " of conveyance to the living principle, the power " and quantity of which, seem to be more con- " siderable in certain conditions of the brain and " nerves;—an inexplicable phœnomenon!" — *Gardiner's Observations on the Animal Œconomy.*

This author evidently confounds secretion with nutrition. In the brain, as in every other organ, there is a separation of certain parts from the circulating mass, for the purposes of nutrition. But we have no certain ground for asserting, that this process is the same with glandular secretion; at any rate, the nutrition of the brain is probably the same, as in that of any other organ. It may, perhaps, admit of a question, whether there is not an absurdity of the same kind, in imagining that the living principle is conveyed from one part to another, as there is in its being secreted in the brain.

" The blood sent to the brain is more spirituous " and refined than the rest of the mass.——I do " not find it to be so.——Yes; but it must be so. " ——Why? Because the animal spirits are se- " creted from it; and all the world knows, that " the animal spirits are the most refined of all " fluids.——Where is this fluid? In the nerves.

"——Cut a large nerve, and shew it to me.——
"You cannot see it, it is so refined.——That is un-
"lucky.——On the contrary; it is the most fortu-
"nate thing in the world; if we could see it, it
"would be good for nothing; but we are sure it is
"there.——How so?——How so? For what other
"purpose but the secretion of this fine æthereal
"fluid, would the most spirituous part of the blood
"be sent by the carotids to the brain?——So that it
"is clear, that the most refined parts of the blood
"goes to the brain, because the animal spirits are
"there secreted; and that the animal spirits are
"secreted there, because the most refined parts of
"the blood goes to the brain."——*Moore's Medical Sketches.*

This is a good specimen of the reasoning usual on this subject.

A new agent has been discovered, which at first was thought likely to develope the mystery of nervous agency. But these expectations were soon found to be fallacious. All that results, as Dr. Monro has observed, is, that a new mode of exciting the nervous energy is known, without any light being thrown on the nature of that energy. If galvanism, however, has disappointed the hopes of physiologists, it has made amends in another science. The whole face of chemistry has been changed (in the words of a late critic) in consequence of convulsions in the limbs of a dead frog.*

Although a certain fulness of the vessels of the brain is essential to its functions; yet, beyond a

* Edinburgh Review.

certain degree, this diminishes and puts a stop to them—stupor, &c. being the consequence. But, on the above supposition of the brain being a secretory organ, the reverse ought to be the case. A greater determination to a gland, increases the secretion from it: the brain, therefore, in the above circumstances, would secrete a larger quantity than usual of the nervous fluid, or whatever other fluid was in general formed in it; and sensation, motion, the functions dependent on it, would go on with more vigour than usual.

It is difficult also to explain, consistently with this hypothesis, the effect of compression from any cause whatever, in abolishing or lessening the energy of the brain; for, compression on a gland, has, in most cases, the effect of increasing the secretions from it. What purpose, on the supposition of the brain being a glandular organ, is answered by the variety of structure observed in this organ? Of its processes, cavities, of the division of cortical and medullary substance? Is there any thing similar met with in any of the glands of the body?

If the nerves are the excretory ducts of the brain, they ought, consistently with analogy, to arise from every part of it—from the extremities of arteries. What becomes of the fluid formed in the upper part of the encephalon, as the nerves only take their rise from the base?

All the secreted fluids have some analogy with the blood, from which they are formed; and by chemical analysis, can be resolved into principles similar to those which constitute the circulating mass: but the nervous fluid, whether of the nature

of electricity, or not, supposing it to possess the properties usually attributed to it, must be totally different, either from the blood itself, or from any of the secretions. The process by which it is formed in the brain, supposing it is actually formed there, can hardly be conceived to be analogous to secretion.

It is here to be remarked, that it is not only in the brain that a certain state of fulness of the blood vessels is an essential circumstance; but that the same is the case in the other parts of the nervous system, particularly the sentient extremities of nerves, in order to the due performance of the functions of those organs. It will hardly be asserted, even by those who suppose secretion to take place in the brain, that the same takes place in the other parts abovementioned. But it appears most probable, that the purpose answered by the connection between the vascular and nervous systems, is the same in all parts. If it is not secretion in the one case, it is not in the other. A certain state of tension of the nerves has been supposed, with some probability, to be the purpose answered by the fulness of the blood vessels connected with them—the same may be the case in the brain.

What becomes of the nervous fluid after it has performed its office? When a muscle continues in action for a certain time, does the nervous fluid continue in it during the whole time of its contraction, or is its presence only necessary to produce the contraction in the first instance, which can afterwards continue independent of it? Is the escape of the nervous fluid the cause, or the consequence, of the

cessation of the muscle? Haller's opinion is, that it exhales through the cutaneous nerves.*—"Exha-"lare per nervos cutaneos non est improbabile. "Lassitudo certe ad motus et sensus superve-"niens inter paucas hores, *per spirituosa medi-"camenta reparabilis* et amitti suadet et repa-"rari."—*Prim. Lin. Physiologiæ,* sect. ccclxxxv. But the circumstance of fatigue being removed by stimulus, by no means accords with the idea of its being occasioned by exhaustion of the nervous fluid; for the excitement thus produced, must occasion a still further exhaustion. The only way in which lassitude could be removed on this hypothesis, would be by a fresh supply of the nervous fluid; and how this is to be done is not explained. Dr. Darwin indeed asserts, that some kinds of stimulus, as wine and opium, increase the secretion of sensorial power; and hence, in some cases of debility, recruit the strength.—Zoonom. sect. xii. 8. But then, how in any case do they produce exhaustion? which effect, however, is attributed to them by the author of Zoonomia. It is manifest, if the increased secretion of sensorial power, occasioned by these stimuli, exceeds the expenditure which they immediately produce, exhaus-

* Haller has here completely contradicted himself: he says, Prim. Lib. sect. ccclxxxv.—"Nutrire non credas nimis mobilem (liquorem "nervosum seil) a quo non expectes adhesionem: id tardi est humo-"res et viscidi." In sect. ccccxvii.—"Quæsitum est, quo spiritus "abeat, a cerebro submissus. *Pars forte exhalat, et partem suspicor "ad fibram adhærescere, ita fieri, ut cum exercitatione musculi inva-"lescant torique crassiores fiant."*

By the "Spiritus a cerebro submissus" must be meant the same as "Liquor nervosus."

tion could never be the consequence of their exhibition. In ordinary cases, therefore, they either occasion no secretion of sensorial power, or not in so considerable quantity as that which is expended by their immediate effect; why then does it otherwise happen in cases of debility?

The relaxation of a muscle, after its contraction, (according to Dr. Darwin, Zoonom. sect. xii. 1. 4.) even though the stimulus continues to be applied, appears to arise from the expenditure or diminution of the spirit of animation previously resident in the muscle. In those constitutions which are termed weak, the spirit of animation becomes sooner exhausted, and tremulous motions are produced. In Sect. xii. 1, 5.—"After a muscle or organ of sense "has been excited into contraction, and the senso-"rial power ceases to act, the last situation or con-"figuration of it continues, unless it be disturbed by "the action of some antagonist fibres, or other ex-"traneous power. Thus, in weak and languid peo-"ple, wherever they throw their limbs, on their bed "or sofa, there they lie till another exertion changes "their attitude." Again, in another place, we read:—"The immediate effect of the action of the "spirit of animation, or sensorial power, on the "fibrous parts of the body, is a contraction of the "animal fibre."—Sect. xii. 1, 2.

In these paragraphs there are obvious inconsistencies. It is stated, that the effect of the action of the spirit of animation, or sensorial power, is the contraction of the animal fibre. which contraction, (for by the expressions, *situation*, or *configuration*, a state of contraction must be un-

derstood), continues in some cases after the cessation of the action of the sensorial power. A muscle may indeed continue in action after the stimulus is removed; but the stimulus is only the exciting or occasional cause of contraction, whereas the sensorial power, or spirit of animation, or certain modifications of it, are supposed to be the perfect and efficient cause of the actions of the different organs, which therefore can never, in any instance, exist independently.

In sect. iv. ii. it is said,—"The spirit of anima-
"tion is the immediate cause of the contraction of
"the animal fibres."—"A certain quantity of sti-
"mulus produces irritation, which is an exertion
"of the spirit of animation exciting the fibres into
"contraction." In the first of these paragraphs the spirit of animation is expressly stated to be the *immediate cause* of contraction. In the second, it is only an occasional cause which *excites* contraction; and the fibres must therefore be supposed to possess a *power* of contracting independent of it, which is merely called into action by the spirit of animation, and thus is, therefore, not the immediate cause of contraction.

In sect. xii. 1, 7.—"It may be supposed, that
"there may exist a greater or less mobility of the
"fibrous part of our system, or a propensity to be
"stimulated into contraction, by the greater or less
"quantity or energy of the spirit of animation;
"and hence, if the exertion of the sensorial power
"be in its natural state, and the mobility of the
"fibres increased, the same quantity of fibrous con-
"traction will be caused, as if the mobility of the

" fibres continues in its natural state, and the sen-
" sorial exertion be increased " If the sensorial power is the immediate cause of the contractions, the mobility of the fibres must be always the same, the quantity of sensorial power continuing the same. By stating that the mobility may vary, the sensorial power not varying, the fibres being at one time more susceptible of its action than at another, the sensorial power becomes nothing more than a stimulus, and is therefore the cause of the contractions only, in the same sense in which the blood may be said to be the cause of the actions of the heart and arteries, or the food of those of the stomach and intestines. The cause by which the parts become susceptible of its action, remains still to be ascertained. If the sensorial power is the real or immediate cause of the animal motions, the fibres, independent of it, are nothing more than inert, or dead matter, and the degree of their mobility must depend solely on the quantity of sensorial power which exists in them. The author himself, in another place, admits this, as he observes—" The contractile fibres
" consist of inert matter; and when the sensorial
" power is withdrawn, as in death, they possess no
" power of motion at all, but remain in their
" last state, whether of contraction or relaxation,
" and must thence derive the whole of this property
" from the spirit of animation."

Sect. iii.—" Hence it appears, that a part of the
" retina, which had been fatigued by action in one
" direction, relieves itself by exciting the antago-
" nist fibres, and producing a contraction in an op-
" posite direction, as is common in the exertions of

"our muscles. Thus, when we are tired with "long action of our arms in one direction, as in "holding a bridle on a journey, we occasionally "throw them into an opposite position, to relieve "the fatigued muscles." But although what is here stated may be really consistent with fact, it cannot be reconciled to the fundamental principles of Zoonomia; for the immediate cause of the action of the muscular fibres is the sensorial power. This is exhausted by the contraction which takes place, and must be still further exhausted by the second contraction, and consequently fatigue must be increased, instead of being lessened. The only way in which the fatigue could be removed, would be by a greater flow of sensorial power into the fibres which had been exerted; for the fibres themselves are not (properly speaking) subject to fatigue: according to Dr. Darwin's Theory, it is only the exhaustion of the sensorial power which constitutes this state.

The expenditure of nervous fluid in muscular motion, must be immense, as it always escapes from the system after the contraction has ceased.

The effects of specific stimuli are inexplicable also on this principle; the nervous fluid being every where the same, why should it be acted on in one part by one application, and in another organ by a totally different agent?

Again, it is well known, if a stimulus is repeatedly applied to a muscular part, within a short space, it no longer produces its effect. This fact, the advocates for the theory in question, are ready to account for, by imagining an exhaustion of the

nervous fluid to have been produced by the previous exertions; but if at this period a different kind of stimulus is applied, the part will often renew its actions; whereas, according to this theory, it ought to remain totally incapable of action, and insensible to the effects of stimuli, having lost that principle on which these causes depend.

A stimulus is called an "eductor of vital æther" in the language of Zoonomia. Here may be asked, how does the stimulus act on the æther? And how does the escape of this last occasion muscular contraction? If there is any specific attraction between the two, would it not be as easy to imagine an attraction between the stimulus and muscular fibres, which should immediately cause their contraction, independent of any intermediate agent?

Dr. Darwin, in sect. xxx. 8. has these words. —"Besides the supposed production of phospho-
"ric acid, and change of colour in the blood, and
"the production of carbonic acid, there would
"appear to be something of a more subtile nature
"perpetually acquired from the atmosphere, which
"is too fine to be long contained in animal ves-
"sels, and therefore requires perpetual renova-
"tion; and in that which life cannot be conti-
"nued longer than a minute or two. This æthereal
"fluid is probably secreted from the blood by the
"brain, and perpetually dissipated in the actions
"of the muscles and organs of sense; but which,
"nevertheless, may remain for a longer time, where
"there is little or no exertion of the animal fibres,
"as in syncope, and in those insects and other ani-

" mals which remain, during the winter, in a tor-
" pid state."

But this æthereal fluid is either the same with the sensorial power, and therefore should not be distinguished from it, or else is obviously inconsistent with that hypothesis; for the sensorial power was all along supposed to be the proper cause or principle of life.

Some have imagined, that the nerves are surrounded with or environed by an atmosphere of nervous emanations; by means of which their influence is extended beyond the space in which they actually exist.—*Reil. Archives of Physiology.*

Hence the faculty of feeling radiates towards all the parts comprehended within the sphere of action of a single nerve, which is its centre.

Fontana, in his work Sur les Poisons, et sur le Corps Animal, p. 117, 118, vol. ii. has some curious conjectures, which have a reference to the present subject.—" La morte qui suit immédiatement l'in-
" troduction du poison dans la sang pourroit faire
" soupçonner qu'il existe dans cette humeur une
" principe plus actif, plus subtil, plus volatil, qui
" êchappe à la meilleure vue et même au micros-
" cope. Ce principe dans cette hypothese paroi-
" troit nécessaire à la vie, et c'est sur ce principe
" que le poison sembleroit porter principalement
" son action."

" Ce qui pourroit faire soupçonner qu'il existe
" dans le sang un principe plus actif et plus volatil
" c'est de voir que le venin de la vipere empêche la
" coagulation du sang tirê des vaisseaux mêmes.

" Dans le premier cas on croiroit qu'il s'est évaporé
" du sang quelque chose qui existe dans le sang
" renfermé dans ses vaisseaux. Dans cette hypo-
" these ce principe actif et vital pourroit-être con-
" sideré comme le resultat de toute l'œconomée ani-
" male sans en exclure les nerfs qui pourroient
" même y contribuer pour la plus grande partie."

In the first place, it may be observed here, that the speculations of this author (Mr. J. Hunter), and some others, respecting the vitality of the blood, are extremely doubtful; and, from an experiment of Dr. Fowler, related in his work on Animal Electricity, it appears to be proved, that certain poisons do not act on this fluid.

This subtile matter must be supposed to possess properties different from any other; and then, why not attribute these properties at once to the animal body itself.

Again, vol. ii. p. 245, he has stated some further conjectures.—" Non seulement le méchanisme du
" mouvement musculaire est inconnu; mais nous
" ne pouvons mêmes rien imaginer qui puisse
" l'expliquer, et il semble que nous soyons forces
" de recourir à quelque autre principe si non
" a l'électricité ordinaires à quelque chose du moins
" de fort analogue à l'electricité. La gymnote elec-
" trique et la torpedo rendent la chose si non pro-
" bable, du moins possible, et l'on pourroit croire
" que ce principe suit les loix les plus ordinaires de
" l'electricité. Il peut-être encore plus modifié dans
" les nerfs qu'il ne l'est dans la torpille et dans le
" gymnotus. Les nerfs seroient les organes de
" même destinés à conduire ce fluide, et peut-être

" encore a l'exciter, mais tout reste à faire. Il faut " auparavant s'assurer par les expériences certaines " si le principe électrique à vraiement lieu dans les " muscles qui se contractent. Il faut fixer les loix " qu'observe ce fluide dans le corps animal, et après " tout cela il restera encore à savoir ce qui excite " et comment s'excite en nous ce principe. Que " de choses incertaines pour la posterité !"

The mere probability of a theory, which is all that is adduced by this author in favour of that which he endeavours to establish, is almost nothing, even were it admitted. But in the present case, it may be doubted whether the speculations of the Abbé can be said to rest even on this ground; with great reason does he conclude:—" Que de " choses incertaines pour la posterité."

Electricity, although a stimulus in general to the sensible and irritable parts, yet, when above a certain degree of intensity, has a contrary effect, depressing or extinguishing altogether the vital principle, particularly if applied to the brain itself. Thus, Dr. Franklin, having passed the electric spark through the brain of six robust men, saw them fall without sensation or motion, with all their muscles relaxed.* Lightning thus injures the functions of the nervous system, or kills. These facts are in conformity with that general law of the animal œconomy, by which stimuli, when in excess, produce depression of the living power; but are incompatible with the idea, that the electric fluid is the principle of sensation and motion, or that agent by the inter-

* Letters and Papers on Philosophical Subjects.

vention of which these functions are performed. It may be added, that animals killed by lightning, or electricity, putrify sooner, and shew less signs of irritability, after the death of the system, than in the cases of sudden death from other causes.

Almost all the speculatists, whose systems successively prevailed in the schools of medicine, adopted some of these hypotheses; and they were thus interwoven with, and formed a part of the most generally received theories. Of the Boerhaavian system, which long and extensively prevailing, exerted a most pernicious influence on the progress of medical science; they formed a distinguished part, and modified, in a peculiar manner, served to give an explanation of many parts of the animal œconomy, which perfectly coincided with popular opinions and prejudices. More refined, and less adapted to the ideas of the vulgar, the system of Cullen, although it rejected the miserable theories of morbid matter, viscidity, and lentor, still retained that of the nervous fluid; and it even appears, that the celebrated inventor regarded this part of his speculations with peculiar complacency. An attack, supposed to be levelled at it, in an article in an early edition of the Encyclopædia Britannica, is related to have considerably annoyed him; and it was in consequence expunged from the subsequent editions of that work.*

It was, however, rejected by Stahl—this most in-

* The article in question was on the subject of æther; the writer was Mr. Smellie, the printer, in whose Memoirs, lately published, it is reprinted entire.

genious speculatist, whose system, according to some, has been misunderstood, and, perhaps, was purposely involved in some degree of obscurity; referred all the functions of the living body to a single principle, and discarded all intermediate natures, vital principle, animal spirits, &c.

Darwin, under the names of sensorial power, spirit of animation, assigned it even more extensive functions than any of his predecessors. But his ideas of its being intermediate between matter and spirit, or able to assume or lay aside the property of solidity, are too remote from all rational analogy, to require a serious refutation, and can be considered in no other light than as an exemplification of the remark of Cicero:—"Nihil tam absurdum quod ab aliquibus philosophis non sit dictum."

De Haen has some good remarks on the present question. Rat. Med. tom. i. p. 337—"Ignoramus prorsum eas quarum ope commercium hoc peragatur, partes; ignoramus qua se lege et tangant et moveant et iterum sistant. In genere novimus necessariam musculi suis cum vasis integritatem, boni nervi toto itinere suo aptitudinem: integrum quem pro sensorio communi habemus locum, verum plures in sententias scissi mutuam harum omnium harmoniam, agendique facultatem minime capimus; nervorum cavitatem, fluidi per eam transeuntis præsentiam, scholæ crepant, sed alterutrum existere nullus mortalium optimis licet armatus miscroscopiis demonstrare potuit. Etiam videntur actiones musculosæ in

" corpore existere quibus communi lege explican-
" dis haud sufficimus."

" Denique nec per se mens ullo corpore tangi,
" Nec quocumque modo connexum impellere corpus
" Nostra potest. Unde est igitur quod metua sese
" Commoveant? Certisque in corpori motibus ortis
" Notities menti adveniat, tum certa cupido?
" Atque ex notitia certaque Cupidine mentis
" Quidam enascantur motus et corpore gliscant?
" Naturas adeo duplices quæ fibula nectit?
" Quidquid enim nectit partes ad utramque necesse est
" Pertineat sic vitta manus sic lora jugales
" Vincula sic ulmo vitem, sic stamina pannos
" Ac vinclum si corpus erit qui prendere mentem?
" Et si incorporeum qui prendere membra valebit?
" Ergo infiniti conjunxit sola voluntas."

Polignac Anti-Lucretius.

Haller, with reference to Sir I. Newton's hypothesis of an elastic æther, says:—" Nihil absurdum " videri debet quod tantæ menti probabile visum."

In reply to this argument *ad verecundiam,* the following passage, from a distinguished medical writer, may be cited.—" Male omnino Neutoni no-
" mine nunquam non venerando abusi sunt scrip-
" tores nonnulli qui opinionem quam tueri cupe-
" rent, in ejus auctoritatem rejecerunt totam quam-
" vis ille solita modesta et prudentia quam laudare
" quam imitari plerique auctores maluere, suam de
" hac re sententiam pro conjectura tantum seu ques-
" tione proposuerit, idoneis argumentis et experimen-
" tis aut refellenda aut confirmanda; sed ne quidem
" Neutoni conjecturas pro veris sumere licet: non
" sic ille imitandus non sic scientia promovenda."

" Utilissimus certe et strenuissimus æther, sed
" nusquam ad questionem deductus ut sui ratio-

" nem redderet, proteo ipso mutabilior et fugacior,
" diu multumque jam frustra agitatus, tandem re-
" quiescat in pace : nam quæ spes prehendendi cui
" in plures jus est transire figuras."

" Nam modo te juvenem, modo te videre leonem
" Nunc violentus aper, nunc quem tetigisse timemus
" Anguis eras, modo te faciebant cornua taurum
" Sæpe lapis poteras, arbor quoque sæpe videri
" Interdum faciem liquidarum imitatus aquarum
" Flumen eras, interdum undis contrarius ignis."

Gregory Consp. Med. Th. tom. i. p. 62.

Yet, if the question was to be decided by an appeal to authorities, these would by no means be found wanting on the other side. Dumas, and Caldani (one of the most distinguished pupils of the Hallerian school) have given an elaborate refutation of the common opinion of the existence of a fluid in the nerves, in their valuable works on Physiology and Pathology. The writer in the Encyclopædia Britannica, alluded to just now, has also considered the more general hypothesis of the æther as the cause of many phœnomena in nature, and attacked it with great acuteness and ingenuity. The writers on the subject of the human mind, as Reid, Stewart, &c. consider the explanation of the communication between the mind and body by means of attenuated fluids, as futile in the highest degree.

To these may be added some admirable remarks by Dr. Friend, in his Defence of his Prælec. Chem. against the criticisms of the Leipsic reviewers, on the subject of some speculations somewhat analogous to those in question ; and lastly, Professor Robinson's Elements of Mechanical Philosophy, p. 349.

The attempts to explain gravitation, or other of the laws of inanimate matter, by means of invisible elastic, or other very subtile matter, are exactly of the same stamp in natural philosophy (it may here be remarked), as those of animal spirits, &c. are in physiology.

It is indeed difficult, or impossible, to conceive any changes taking place in matter unaccompanied with motion; but it is nevertheless hardly allowable to assert, that the existence of any other is impossible. At any rate, as no connection can be traced between motions either of the nerves themselves, or a fluid contained in them, and the functions which these organs fulfil, it is unphilosophical to frame such hypotheses, and only loading the subject with unnecessary conjectures. It may perhaps be asserted, without going too far, that if the existence of a nervous fluid, or of vibrations in the nerves themselves, was ascertained by experiment, or observation, the manner in which sensation or motion take place, would be so far from being developed, that all that would result would be, that the number of phœnomena, of which are totally inexplicable, would be increased.

The brain has been commonly denominated the sensorium commune—the seat of the soul. If by this language it is only meant, that this organ is, somehow or other, concerned in sensation; and, perhaps, imagination, memory, and the other functions, more purely mental,—the assertion may be, perhaps, considered as supported by facts; but nonothing farther can be concluded on any just grounds. If the brain is literally the seat of the

soul, the relation of the soul to space, is of course admitted; and, with this, almost necessarily, it is supposed to be extended; consequently one of the strongest arguments in favour of it is immediately overthrown. It seems too much to assert, that ideas are connected with, or depend on certain states or conditions of the brain. The following citations from a late distinguished physiological writer, will vindicate the utmost scepticism on this subject.

"Rien n'est plus difficile que d'estimer au juste "les fonctions du cerveau qu'il exerce par lui-"même. Cet objet tient à ce que la metaphysique "offre de plus relevé. On n'a point encore reussi, "on ne réussira peut-être jamais à determiner les "operations intellectuelles qui coincident avec telle "ou telle modification sensible du cerveau. Nous "savons cependant qu'il entre en activité pour per-"cevoir les sensations, et qu'il se reflechit sur elles, "d'une maniere également active, pour créer l'at-"tention, la pensée, la contemplation, la memoire, "l'imagination, et tous les phenomenes de l'intel-"ligence."—*Dumas Princip. de Physiolog.* tom. ii. p. 256.

"La maniere dont s'exercent les operations de "l'esprit nous est si peu connue que nous ne sommes "pas fondes a les deduire du tel ou tel état particu-"liere du cerveau, et les resultats des *recherches* "*anatomiques* sont trop incertaines, trop variables "pour qu'il nous soit permis du rien conclure de "positif ni de satisfaisant."—*Ibidem.*

"Il est impossible d'opposer des responses victo-"rieuses aux arguments sur lesquelles on se fonde

"pour transporter ailleurs que dans le cerveau le "*sensorium commune*, le principe commune du "sentiment et de la vie. Les observations du "Rhedi, de Bartholin, de Duverney, de Littre, qui "l'ont trouvé converti en uné espece de bouillie, "celles de Meri, Wepfer, Rhedi, qui ont vu des "enfans et les animaux venus à terme, vivre quelque "tems privés de cet organe, enfin les expériences "qui demontrent sa parfaite insensibilité dans une "portion considerable de sa substance, tout cela "n'est rien moins que favorable à l'opinion vul-"gare dans laquelle on juge le cerveau digne de "representer le *sensorium commune*, la source "commune du sentiment et le vrai siege de l'ame." —*Ibidem*, p. 258, note.

Perhaps, in the above passages, some degree of inconsistency may be observed; but they are, on the whole, well deserving of attention, and tend to create some doubts, even as to facts considered as thoroughly established.

Professor Monro argues against the opinion, that the living and ruling principles, which are called the mind of the animal, are seated within the head entirely, occupying there a sensorium commune; by observing, that though a wound, beyond the place at which a nerve is cut, does not excite pain, yet there are effects following the wound which cannot be accounted for on mechanical principles.*

The question whether sensations are perceived in the organ in which the material impression takes

* Monro on the Nervous System.—See Diderot's Letter on the Blind, p. 29.—English Translation.

place, or whether (as seems to be the most prevalent opinion) the immediate seat of perception is the brain, or *sensorium commune*, seems to be one which there is no possibility of determining, and which, most probably, will never admit of solution. It is imagined by many, that external objects excite certain motions in the organs of sense. These motions are propagated along the nerves to the brain, where they give rise to sensation. Certain vestiges or traces of these motions, or the motions renewed in a slight degree, according to some, occasion memory and imagination.

The objections to this hypothesis (if it deserves the same), have been already anticipated in a great measure. What connection is there between motion and sensation? still less between motions or any traces left of these and the other intellectual functions. How could these vestiges remain in the soft, pulpy substance of the brain, particularly when the motions of the blood in the vessels would perpetually tend to obliterate them? The renewal of these motions, after they have ceased, is, as already observed, a supposition attended with insuperable difficulties. Dr. Darwin imagines these sensations are merely certain actions of the organs of sense, excited by external bodies, and the ideas of memory, or imagination, the same actions taking place in a weaker degree; he conceives an analogy to exist between these actions and the contractions of muscular fibres. It may, perhaps, be admitted, that the observations and arguments adduced by this author, tend to prove, that the organs of sense are not, as has been generally taken for granted, merely

passive in the taking place of sensation, but that they are excited to certain appropriate actions.* There is, however, a wide difference between this supposition, and the considering these actions as actually constituting sensations or ideas.

This subject cannot be better concluded than with the following remark of D'Alembert, made with reference to the same or similar inquiries.—"Sur "tous ces objets l'intelligence supreme a mis au "devant de notre foible vue un voile que nous vou- "drions arracher en vain. C'est une triste sort "pour notre curiosité et notre amour propre; mais "c'est la sort de l'humanité."

Des Cartes seems first to have refuted, or called in question, the theory of perception of the Peripatetics; † and he substituted for it the idea of motions, propagated from the organs of sense to the brain.—*Iter per M. C.* p. 153.

"Semet ipsum expressis verbis plurimis in locis no- "tasse sensum tactus diffusum esse per omne cor- "pus et per omnia organa aliorum sensuum, visio- "nem, gustum, perceptionem sonorum et odorum "non produci nisi ope motus localis nonnullorum "corporum, attingentium et moventium organa di- "versorum sensuum. Revera si ille motus non suffi- "ceret faciendo ut objecta illa anima percipienda ex- "hibeantur, species intentionales, qui in ejus locum "substituantur, non magis aptas natas esse produ- "cendæ isti perceptiones."

The Peripatetics imagined the soul to be diffused throughout the body. To the Cartesian hypothesis,

* See Note A. † Species Intentionales.

which places it in the pineal gland, it was objected, that if the soul existed in an extended substance, it might as easily be conceived to be diffused throughout the whole system, as a very small part of it, if it existed in an indivisible point of this gland, there was a portion of matter not extended. Thus, either extension was attributed to mind, or the absence of this property to matter, contrary to this philosopher's principles. If it is said, that the soul exists in the pineal gland potentionally, not as body exists in place, but only as producing certain effects; according to the same idea it might be said to exist in the whole body, because every where its agency is evident.——

"Ubi tu doces animam collocatam esse in glan-
"dula pineali, vel existimas illam omnem istius
"glandulæ occupare partem vel tantum aliquam
"ejus indivisibilem partem. Si illa occupat om-
"nem glandulæ extensionem, illa igitur etiam ipsa
"extensa est: hac enim consequentia omnino simi-
"lis est illi quam tu formas contra philosophos il-
"los qui adserunt, animam per omne diffusam cor-
"pus esse. Quod si illa ejus tantum indivisibilem
"partem occupet, potest igitur dari aliqua pars
"materia pars quæ indivisibilis sit, et non extensa:
"atque hac ratione admittendo hanc disjunctivam
"anima proprietatem quondam aseribis quam non
"agnoscis nisi in materia vel materia largiris ali-
"quod attributum quod omni alia occasione ipsi
"denegas, quodque juxta principia tua contendis,
"quacunque intelligatur ratione vel esse attributum
"nisi animæ spiritualis."—*Ibidem.*

The objection here made to Des Cartes, might,

with equal justice, be applied to all those philosophers who imagine an immaterial substance situated in the brain; or, in other words, who believe the brain to be the seat of the soul: for, consistently with the arguments used to prove that matter is not susceptible of intelligence, the soul cannot be extended, and consequently not be properly said to have a local habitation; if it exists in the body, it must be in a manner peculiar to itself.

"Cartesius ejusque sequaces Meyssoneirius, Regius, Hogelandius existimant glandulam hanc in medio ventriculorum in vigilia spiritibus perpetuo distentorum si tam omnium objectorum motus excipere, et animam in hac sola per nos motus sensilia externa et omnes ideas quæ in a quinque sensibus proficiscuntur apprehendere, tanquam in centro discernere et deinde ejus ope spiritus ad varios nervos mittere, sicut in speculo spherico exilia omnia eo ordine recipiantur quo in campo vel musæo sunt."—*Bartholini Anatomia*, p. 496.

"Hanc ob causam figuram conicam ei accommodat Meysonius, quia individua plus spatii quam species aut genera requirunt, moveri antem has ideas diversi-mode per motum spiritus animalis, sed semper reperiri junctas perpetuam est, secundum earum æqualitatem vel inæqualitatem verum et falsum componi, comparatas inter se."—*Ibidem.*

It does not appear, that the doctrines of Des Cartes, relating to the functions of the living system, were adopted by many of the physicians or anatomists of that day. Steno, the intimate friend of this philosopher, was persuaded, that the Treatise

de Homine was merely the figment of imagination, and had no relation to nature.*

*Willis illustrates the mode in which objects are perceived, by a comparison with the camera obscura. The animal spirits, he supposes, are brought to a focus, so as to form a kind of images or pictures. He then asks, what is the power which recognises the images thus delineated; or, as he expresses it: —"Quomodo se sentire sentiat?" And resolves it into an original law of the human frame.—"Corpus ita comparatum esse ut ex anima simul et corpori animi per ejusmodi translatum constantia resultat quibus unicuique animali in finis et usus ei destinatos opus fuerit."—He supposes that in brutes, the soul is not conscious of sensations, although these sensations really exist. This incomprehensible hypothesis has been maintained by a late celebrated writer.—"We may conceive two kinds of feeling; one with, and the other without consciousness; the latter, perhaps, resembling that kind of feeling, which we may suppose, inherent in vegetables."—*Monro on the Nervous System.*

Willis compares the human frame to a musician playing on an instrument; the rational soul being the musician that directs the motions with design and intention; whereas the body of an animal is analogous to an instrument, set in motion by an extraneous impulse, without rule or design. This, however, relates only to those animals whose structure is less perfect; for others, he states, possess powers more analogous to those of man. His reasoning to prove, that mere matter may be capable

* De Anima Brutorum, p. 31.

of sensation, is curious.—" Inter corpus insensile " ac sensile haud mitto majus discrimen est quam " inter accensum in accensumque et tamen hoc ex "illo fieri passim cernimus, quid ni pariter existe- " mus sensile ex insensibile fieri ?"

The sensations which are felt by persons who have suffered amputation, and referred to the part removed, are among the most commonly cited proofs of the soul having its seat in the brain, and receiving impressions through the medium of the nerves. It is said, that whether an impression is made on the extremity of a nerve, or on any other part of its length, the ultimate effect will be the same; in the same manner as a person holding a stick with his hand, will experience the same sensation, whether the end or any other part of it is struck against an obstacle. This was the explanation given by Des Cartes in the first place, and which has passed current with most inquirers into this subject ever since.—" Imbecilitatem hujus ratiocinii probavit " experientia duplici quo manifesto evincit nos posse " dolorem sentire ac impressiones objectorum iis in " loris ubi anima nostra non est. Prima est eorum " quibus amputatum brachium quique sæpe sen- " tiunt dolores eo in loco ubi digiti existerent nisi " brachium fuit resectum licet digiti ipsorum non " amplius adsint, ostendit itaque cum impressio " objectorum in nostrum corpus nequeat consis- " tere nisi in agitatione fibrarum et nervorum " ab omnibus partibus per id dispersorum haud " necesse esse ut anima sit extensa juxta ductum " istarum fibrarum et nervorum sufficere vero ad " percipienda objecta, illa agitatio ut possit com-

"municari cum aliquo loco præcipuo ubi sedes "sit anima: pari ratione ac motus productus ab "occursu corporis duri mollis lavis aut asperi "communicatur cum manu baculi auxilio."—*Iter per Mundum Cartesii*, p. 11.*

Others have explained the phœnomenon in question from the habit we are under of referring all sensations to the extremities of the nerves, and consequently supposing that the effects of the habit, or the associations thus formed, continue after the removal of the limb.—*Vide H. Cullen Dissert. Inaug. De Consuetudine.*

Dr. Darwin gives an explanation of this curious fact, according to the general principles of this system, thus:—"Our ideas of the shape, place, and "solidity of our limbs, are acquired by our organs "of touch and of sight, which are situated in our "fingers and eyes, not by any sensation in the "limb itself. In this case, the pain or sensation, "which formerly has arisen in the foot or toes, and "had been propagated along the nerves to the central "part of the sensorium, was at the same time accom-"panied with a visible idea of the shape or place, and "with a tangible idea of the solidity of the affected "limb. Now when these nerves are afterwards af-"fected by any injury done to the remaining stump, "with a similar degree or kind of pain, the ideas "of the shape, place, or solidity of the lost limb "return by association, as these ideas belong to the

* Refutant hanc sententiam (scil animam in *proximo* sentire) do-"lores post amputationem superstities."—*Haller Prim. Linea*, sect. 366.

See also Porterfield on the Eye.

" organs of sight and touch, on which they were " first excited."—*Zoonom.* sect. iii. 6, 3.

Professor Dumas has given a very ingenious hypothesis.—" C'est une chose fort connue que l'homme " eprouve souvent de la douleur dans les membres " qui lui ont appartenu et qui ne font plus partie de " lui-meme. Il arrive frequemment qu'un rapporte " ces douleurs à un bras, à un jambe retranchée du " corps depuis long-temps: et les chirurgiens as- " surent avoir ou plusieurs personnes les ressentir " encore six années après l'amputation, dans la par- " tie même qu'elles n'avaient pas. Si l'on convient " avec moi que la sensation est une mode resultant " des actions combinées de tous les organes du sys- " teme sensible, un mode repétée dans toutes les " parties, et qui prend dans chacun une charactere " particuliere: si l'on si rappelle d'ailleurs combien " differens organes ont de choses communes en- " tr'eux et jusqu'à quel point ils peuvent se sup- " pléer l'un à l'autre on concevoir la possibilite " qu'un homme privee d'un bras, par exemple, " eprouve une sensation tout semblable à une de " celles qu'il eprouvoit lorsque son bras vivait avec " lui. Comparant ensuite cette sensation presente " avec la sensation passée que lui rappelle la memoire " ilest naturel qu'il juge ces deux sensatiens iden- " tiques, c'est-à-dire qu'il appercouvri entr'elles un " rapport d'egalite et quil attribue toutes les deux à " la même partie, des termines necessairement dans " cet acte par la force invincible de l'habitude."—*Principes de Physiologie,* tom. ii. p. 150; see also p. 250 of the same volume.

To the first of these theories may be objected, in

the first place, all those difficulties which are necessarily connected with the general system, relating to the manner in which sensation is produced, on which it is founded, and which has been already considered. Besides these objections, it may be asked, why all the sensations which the person experiences in the stump, are not referred by him to the limb which has been removed, supposing this theory to be true; for in all, the nerves which proceeded to the extremity are affected; when the patient presses with the end of the stump on a hard body, he ought to have the same sensation as before the amputation he would have experienced from placing his foot on the ground; and the same in any other case. It may perhaps be said, that the presssure being made on the skin covering the stump, the effects will be different from those which result from an internal cause; but as the pressure must, if at all powerful, extend its effects to the subjacent parts, this consideration does not seem sufficient to remove the objection.

With respect to the other theories, they seem to be fundamentally the same, inasmuch as they ascribe the illusion to the effect of habit and association of ideas, which, perhaps, is the most plausible explanation that can be given of this phœnomena; but as the mode in which sensations are produced in general, is not ascertained, it cannot be supposed that any anomaly respecting this function should admit of any satisfactory elucidation.

The speculatists on the cause of life may be divided into three principal classes—those who refer it to an immaterial principle—those who

imagine something distinct from the immaterial soul, and separate from the body—lastly, the Materialists. The first class may be again distinguished into—first, the Stahlian school, who believe that all the functions of the living system are produced by the rational soul, judging what is most conducive to the health and safety of the whole; in other words, that the vital and natural functions are occasioned by the agency of the *will*, with a view to some determinate end and design, like those actions which are usually denominated voluntary.—Secondly, others, who do not attribute the actions in question to the will, but to the soul or immaterial principle, acting in some unknown manner. These imagine, that all the actions of the system are owing to the same cause; operating differently. This mode of considering the subject, Whytt, and perhaps Cullen, have adopted, with some who are intermediate between this opinion and that of Stahl.

The Vitalists acknowledge an immaterial substance as the cause of the phœnomena of mind, but do not attribute to it the production of the vital and natural motions. These they account for by supposing, that there is in the system either a peculiar substance distinct both from mind and body—of the nature of it, there is no agreement. Many suppose it to be only a finer species of matter; and others, something distinct and intermediate between mind and matter. Others are of opinion, that the vital functions are merely the result of organization, and not of any distinct principle; yet, admitting an immaterial substance as the source of thought, they are not to be ranked among the Ma-

terialists. This last class consider the body as constituting the whole of the animal—thought and sensation, as well as the involuntary motions, being only modifications of the organs. Even amongst this class, however, a diversity of sentiment is to be recognized: whilst some conceive organization to be the only source of the functions in question, others are disposed to refer the phœnomena to some unknown modifications of matter, independent of structure, or any arrangement of parts.

TOUCH.

THE sense which is never known to be wanting, and which appears to be most essentially connected with the existence of our bodies, is touch. It is also, probably, the sense by which the existence of external bodies is suggested to us. Without it, all the other sensations, as colour, taste, and smell, would have been conceived to be only modifications of our own minds. Impenetrability, that property of matter, supposed most essential, is made known to us by the sense of touch.* When we press on an external body, and feel a resistance, something independent of that which feels, necessarily occurs to us; and we hence infer the existence of a solid, extended, impenetrable substance. Here, however, there is evidently room for fallacy. If we suppose a particular species of matter, which had the same property of repulsion with respect to our bodies, as the repellent end of the magnet has to iron, there can be little doubt that the sensation which we should receive from this body by means of touch, would be the same as if its sphere of repulsion were a solid impenetrable mass; and this last idea would be that which we should adopt respecting it, if the error was not corrected by the sight or other senses.

* Gravesende Phil. Newton. Inst. sect. 16.

All that can properly be inferred is, that something resists. What this is, whether a solid impenetrable mass, or a repulsive power, our senses give us no information.

That part of the body, in which the sense of touch exists in greatest perfection, is the hand and fingers. The delicacy of the skin, at the points of these especially, and the facility with which they are applied to external objects, from the division into separate parts, give to these organs great advantages in this respect. Buffon has contended, that if the hand was divided into a greater number of parts ;—if, for example, there were twenty fingers, the sense of touch would exist in greater perfection than at present, and mankind would thence derive more extensive and clearer information. But it may be doubted, whether on the whole, much advantage would result from any of the organs of sense being so constructed, as to give a greater variety, or more perfect sensations, unless the power of attention was also proportionably increased.

Still less can the speculations of certain philosophers, that man owes to this sense alone his superiority over other animals, be assented to. But it cannot be denied, that from it more certain information is derived of external bodies, than from any of the others. The delicacy of the sense of touch (like all the other senses), may be much increased by habit and exercise. Boyle relates the history of a music master, who being deprived of sight, could distinguish colours by means of the sensations imparted by touch. He was guided in this respect by the greater or less degree of asperity which he dis-

covered in bodies differently coloured. Black and white both agreed in being characterised by a considerable roughness of their surfaces of bodies; and he was thence a long time in learning to distinguish them. Black, however, exceeded in this respect; green came next to white; blue next; and gradually the others. Red having the most equal surface, and being most polished.—*Boyle Tractat. de Coloribus*, p. 18.*

Similar instances have been reported by others. It cannot be doubted, that this extraordinary degree of sensibility is principally to be ascribed to the greater degree of attention which a person, deprived of the sense of sight, might be supposed to apply to the perceptions from touch. But it is not impossible that some alteration in the structure of the organ of touch might be produced in the cases in question, from a greater flow of blood, distension of the papilla of the skin may possibly take place in handling a body with great care, thus increasing the sensibility of the skin by augmenting the tension of the sentient extremities of the nerves, analogous to what happens in the penis and clitoris, and in the tongue.

The sensation of touch, like all others, continue for a certain time, in many cases, after the removal of the cause exciting them. Thus, when a hard substance has been long pressed on a part of the body, after it is removed, the sensation which it caused, still continues.

* For some very curious observations on this topic, see Diderot's Letter on the Blind, and Le Cat. Traité des Sens.

TASTE.

THE sense of taste resembles touch in this respect, that it is excited by substances which come into immediate contact with the organs, to another sense—that of smell; it has also analogies of another kind, the same substances having often the property of acting on the organs of both, and both having a relation to alimentary matters. This sense seems to be more acute in many other animals than in man. It seems also to be less perfect in civilized life, than among savages, who are accustomed to trust to it almost entirely for information, as to the salubrity of the articles which they use for food. Some instances have occurred (although these are rare), of persons who have been destitute of this sense. There is perhaps greater diversity as to the sensations derived from taste, than from any others of the external senses. In the different periods of life, in different temperaments, diseases, and, by habit, the sensations of taste, are so much modified as to have become proverbial.

It is observed by Dr. Gregory, Consp. M. tom. sect. 152—"Insignisquoque et fere incredibilis est "vis consuetudinis in voluptates aut molestais sensus "exigua autem in sensum ipsum et nulla omnino in

" perceptionem qualitatis rei externæ quam sensus
" suggerit. Nemo enim sanus vel natura vel ulla
" consuetudine mel pro absynthio aut absynthium pro
" melle aut amarum pro dulci gustare potest: quam-
" vis aut singulari corporis constitutione aut demum
" sola consuetudine amarissima ista herba dulcissimo
" melle gratior et jucundior gustui fieri possit."

Tastes, at first nauseous, are often those which by habit become most agreeable. It appears that the want of impression on the organ may occasion a positive sensation in some instances—this is analogous to the effects of cold. Distilled water, to those accustomed to this fluid, as it usually exists, combined with neutral salts, and different aeriform fluids, gives a taste which is extremely disagreeable, and is not merely insipid. In order to produce sensation, all that is required is a change in the state of the organ; and this may be occasioned often by a removal of an accustomed impression, as well as by the application of an external agent.

SMELL.

SMELL resembles taste in most of the circumstances just stated. Like it, it exists in greater perfection in many animals than in the human species, and seems to have its energy diminished by the want of attention to the sensations derived from it, in a civilized state. It has, in many instances, an effect on the appetite for particular substances used as food; but it has also an evident influence on other parts of the system. The application of many odorous substances produces powerful effects on the nervous system—syncope may be induced by this means. On the contrary, this state may be removed by stimuli, which act on the olfactory membrane—perhaps ammonia, and other substances, which act in this last manner, may rather be considered as stimuli, which excite the organs of respiration, from the sympathy which exists between these and the olfactory membrane, than as merely odorous substances. In many animals this sense influences the venereal appetite.

HEARING.

THE object of the sense of hearing is sound on the vibrations of hard or elastic bodies, which are communicated to the organ by means of the air, in general. Other media, however, it appears from some experiments, answer this purpose better—as water, as is shewn by observations made by divers.

This sense resembles sight, in requiring the aid of experience to form accurate perceptions. The distance, direction, and other circumstances relating to sound, being only ascertained by this means. The perceptions of the sense of hearing are next to those of sight, recalled by the memory with the greatest distinctness: the reason of this may possibly be, that any sound, or succession of sounds, may be, as it were, *silently* repeated by the use of the organ of voice, of the tongue, lips, &c. (without the expiratory motions necessary to the production of sound), and thus the idea of the particular sound be excited by association.*

* Vide Miscellaneous Observations on some Points of the Controversy between the Materialists and their Opponents, 1781.—p. 62, note.

The sensation excited in the organ of hearing remains, as in the other senses, for a certain time after the impression ceases. If this was not the case, there could not possibly be any sensation of continued sound; for sound in the sonorous body consists of vibrations which succeed each other at very short intervals.

VISION.

PREVIOUS to the grand discovery of the manner in which images are formed on the retina, many suppositions were made to explain this very important and curious function. The great topic of dispute was, whether vision was performed by emission or reception. The opinions of Aristotle and Plato were opposed to each other on this point. The Stoic philosophers again imagined, that the rays of sight were emitted from the eye, and impinging on objects, were reflected again to the eye, and thus caused sight. The followers of Epicurus supposed that visible species proceeded from the objects to the eye.*

The great discovery, however, was made by Kepler at length of images of external objects being formed at the bottom of the eye, which were of course concluded to be the cause of our perceptions of objects by sight. It is well known, that by removing the sclerotic and choroid coats of the eye of any animal, and placing it in a proper situation, a beautiful picture of the objects placed opposite will be seen in an inverted position from the crossing of the rays in their passage to the retina; this organ be-

* Diogenes Laertius. Riolan in Fernel de Abditis Rerum Causis, p. 117.

ing a complete camera obscura. The rays undergo a refraction, first, in passing through the cornea; secondly, in the lens crystalline, and again, in the vitreous humour. The differences of the refractive powers of these causes occasion corresponding varieties in vision.

The different refrangibility of the rays would have the effect of rendering objects coloured, according to some, unless there existed in the senses of the eye a structure analogous to that of acromatic telescopes, by which this inconvenience is obviated. This has been denied by others, and the want of colour of visible objects from this cause attributed to a different principle.

This is all that has, or, probably, that can be discovered concerning the mode by which the mind perceives external objects by means of the eye. All that has been advanced, with regard to any further organical affection, is merely hypothetical; motions along the optic nerve, or a fluid contained in it, are a very common hypothesis. These theories, however, have been sufficiently discussed in the preceding pages. Dr. Darwin, more lately, has made public some speculations respecting sensations particularly applying to this sense; of which, all that can be said is, that they shew great ingenuity, and perhaps are founded on more plausible reasonings than any of the preceding theories.

There are circumstances relating to the objects of sight, which the eye does not immediately perceive, but which are, notwithstanding, discovered by the intervention of the experience and observation derived from the sense of touch, and by com-

paring together different perceptions of sight. Magnitude is of this kind. Every object that we see must necessarily appear of a certain magnitude, its image on the retina being of some size or other, depending on the angle formed by the rays coming from it to the eye. This is the *visible* magnitude of the object, which is different from the dimensions which we attribute to it, or the real magnitude; it serves only to suggest this to the mind, and then vanishes so rapidly, that we find it impossible to retain it.*

Distance is likewise not immediately distinguished by sight, for whatever distance an object may be really placed at, it will occupy the same place on the retina; and, supposing it to move in the direction of a right line forwards, it will not be seen to move. With respect to motion in a lateral direction, in which case the image of the object is shifting its position on the retina, the motion will be necessarily distinguished.

The first who advanced this proposition was Bishop Berkeley, and it was soon after confirmed by the celebrated case published by Cheselden, which has been quoted by almost every writer on this subject since.

An object necessarily appearing smaller, the more remote it is, when we know the real magnitude of an object, we judge of its distance by the diminution of its visible magnitude; and the distance being known, we determine its real magni-

* In Dr. Reid's Enquiry into the Human Mind, is a very full discussion of this subject.

tude by means of the visible magnitude. Distance is also judged of by the diminution of the intensity of light, by the indistinctness of the appearances of the objects, and by the intermediate objects which are interposed; and, as some suppose, by the angle formed by the optical axes; it is probable that the motions of the muscles of the eyes, by which they are directed, so as to point at the objects, may be associated with the ideas of particular distances in the mind.

From these principles, which are generally recognised by writers on optics and physiology, many deductions may be derived, and explanations given, of well known facts relating to the perception of visible objects. These may be found also, in many of the writers on metaphysical subjects, as Malbranche, Berkeley, Condillac, Stewart, and especially Reid's Inquiry into the Human Mind, and a Treatise on the External Senses by Dr. A Smith, published in a volume of his posthumous works. It is perhaps a subject which may be said to belong either to metaphysics or physiology. Strictly it belongs to the latter science, as it admits of being illustrated by experiment.

The cause of perception of objects in their true position, although they are inverted in the representation on the retina, is a topic of enquiry, which has produced a multitude of hypotheses.

One very common solution of the question has been, that the sense of touch corrected the erroneous perceptions of sight. But, persons born blind, and restored to sight by an operation, see objects in their proper position; we have no reason to

suppose that they do not see them in the same situation as others, before they could have had time to have recourse to touch, so as to compare the reports of the two senses together; at least before any association could have been formed between the ideas of visible and tangible position in the mind.

Haller says:—"*Situm* partium objecti visibilis "anima eum esse judicat quem hæc partes in ob- "jecto habent, non eum inversum, qui est in retina. "Hanc correctionem anima absque experimento in "homine qui cæcus natus est et animalibus conti- "nuo callet, ut per certa experimenta Hominum "innotuit, quibus cum nullo ab ipso natali die visu "essent gavisi, acus ocularia subito oculi usum "reddidit."—*Prim. Lin.* sect. DLXIII.

It is utterly incredible that, as Mr. Le Cat supposes might possibly happen, the inversion of appearances might cause a part of the astonishment which persons so situated feel on first seeing, and that at the same time the ideas which they had acquired by touch, of the true position of objects, should enable them at once to rectify the delusion. "Que la sensation renversée aura fait une partie de "l'étonnement dont ils furent saisis à l'aspect de la "lumiere et que dans la foule ils n'auront pas dis- "tingué cette singularité mais en renversement "n'aura rien renverse dans leurs idées bien éta- "blies par les longues leçons de leur vrai maître, ce "sentiment du toucher."—*Traité des Sens*, p. 418.

If this was founded on fact, distance might be perceived by sight at first, contrary to what is known to be the case; for the experience of the distance of objects, which had been acquired by the

sense of touch, might be at once transferred to the perceptions of sight, as easily as is supposed by M. Le Cat to take place with respect to position.

Others have thought, that the mind traces back the object along the visual ray, and thus refers it to its true position. This hypothesis, reduced to a form less remote from general apprehension, has been stated thus:—that we judge of the situation of objects by the way in which we direct our eyes in order to behold them, we thus determine those objects or parts of objects to be above, to see which distinctly, we lift up our eyes, and vice versa.

* Dr. Reid has generalised the phænomena so far as to have proved, as he supposes, that every visible point is seen in the direction of a strait line, passing from its position on the retina, through the centre of the eye. It follows, from this law of vision, if admitted, that the whole of the object is seen nearly in its natural position; (*nearly*, for it is not entirely so, the line in question not coinciding with the visual ray necessarily, although it may do so), as it is painted inverted on the retina; whereas if it had been painted erect, the same law prevailing, it would have been seen inverted, or nearly so. Dr. Reid attributes the discovery of this law of vision to Dr. Porterfield; erroneously, however, †Kepler, the discoverer of the seat and manner of vision, having taught the same, although the

* Reid's Inquiry into the Human Mind, passim.

† Paralipomena in vitellionem, cited by Wells.

It appears that the inference as to the cause of vision being erect, while the images were inverted, was deduced from this supposed law.

greater part of writers on optics, have supposed that the apparent directions of objects coincided with their visual rays. *Dr. Reid and Dr. Porterfield seem, however, to have illustrated the law of vision in question, and to have brought more proofs in favour of it than had been done before.

Bishop Berkeley's celebrated Theory of Vision is well known, and that part of it which refers to the present question, consists in the following propositions:—that the situation of objects is merely relative, and depends on the place which each occupies with regard to the neighbouring ones. We call those upper, which are placed towards the heavens, and those lower, which are nearer the earth, and their position being presented on the retina, no fallacy can arise to us; this philosopher, denying any relation between visible and tangible position.

Perhaps this view of the subject may be the most philosophical, and, on the whole the most appropriate situation of the difficulty in question. The following remarks of Gravesende, may, however, be added as completing it.

"Pictura in Fundo oculi est inversa: unde quæ-
"situm quare objecta erecta apparant? Quæstione
"alia respondemus, an quis melius concipiat nexum
"inter idras in mente et figuram erectam quam in-
"versam? Nexum nos nullum percipere fatemur
"experientia autem docet nexum dari inter pictu-
"ram inversam in oculo et objecti erecti ideam et

* "Et omnino inversæ species debent sisti in retina alioquin nos "inversa cuncta videremus non erecta quod Keplerus existimat ex-"inde quia in passione patientia agentibus e regime oportet esse con-"traria."—*Bartholini Anatomia, Quartum Renovata*, p. 521.

"præterea nihil novimus."—*Institut. Philosoph. Newt.* vol. ii. p. 282.

Some have supposed that we judge of the positions of objects relatively, not to the heavens or earth, but to our own bodies, referring those to the upper parts which are nearer our heads, and those to the lower which are nearer our feet.—*See Muschenbroek. Institut. Physices.*

Dr. Wells, in his Essay on Single Vision with two Eyes, has some very curious and original speculations on visible position and visible motion. He observes—"that in the estimates which we "make by sight of the situation of external objects, "we have always some secret reference to the po- "sition of our own bodies with respect to the "plane of the horizon, and from this cause, we "often judge such to be at rest, whose relative "places to us are continually changing, and "others to be in motion, although they may pre- "serve, in regard to us, the same distance and di- "rection." He afterwards asks, "what is there "within us to indicate these positions of the body? "To me it appears evident, that since they are oc- "casioned and preserved by combinations of the "actions of various voluntary muscles, some feel- "ing must attend every such combination, which "suggests from experience, perhaps, the particular "position produced by it. But in almost all the "positions of the body, the chief part of our mus- "cular efforts are directed towards sustaining it "against the influence of its own gravity. Each "position, therefore, must be attended with a feel- "ing which serves to indicate its relation to the

"horizontal plane of the earth; and consequently "if our bodies possessed no gravity, or if the thing "were possible, had we been created disembodied "spirits, but with the same faculties of perception "which we now enjoy, we could no more have "judged one line to be perpendicular, and another "to be parallel to the horizon, than we can at pre- "sent determine, without some external aid, which "is the eastern and which the western point of the "heavens."—p. 86—7.

This theory is directly the reverse of that suggested by Dr. Darwin, relating to this subject. He imagines, that we balance our bodies by attending to the changes in the visible appearances of surrounding objects; instead of these last being influenced by the former circumstance, as Dr. Wells supposes.

Dr. Darwin does not very satisfactorily answer the objections which may be brought to his hypothesis from what happens to us in the dark. We find no difficulty in preserving our equilibrium when we are without the help of visible appearances to direct our efforts. Dr. Darwin attributes the incurvation of the path described in these circumstances, to the balance being lost, and the consequent inclination of the body to one side. But it is evident that this explanation will not apply to a person standing still in the dark. Yet a person so circumstanced, must use certain efforts to preserve his equilibrium, and these can be directed only by certain feelings which attend the inclination of the body to either side. A person standing on an height is in danger of falling, not be-

cause he is without the usual visible objects to ascertain his position, but from the influence of terror; and from the idea of falling, vertigo is induced in these circumstances in consequence of certain associations.—*See Zoonomia, on Vertigo,* vol. i.

The next question is, why do we see objects single with two eyes?

The first hypothesis invented (after the discovery of the general manner in which vision is performed) was that of the junction of the optic nerves. Whether this union actually exists, or not, seems to be doubtful; but it may be observed, that the supposition of its causing the unity of sensations of sight is founded on the particular theories of the mode in which the organic affection attending this function is produced: viz. that some kind of motion is continued along the nerves to the brain; for unless this is really the case, the union of the nerves would not produce a union of the sensations. And again, if such a cause as this,—fixed, mechanical, was actually the reason why objects appear single, it would follow, that in no circumstances whatever could they appear double.

It is well known too, that certain animals, in whom the nerves seem to coalesce in the same manner as in man, yet (we have every reason to believe), see different objects with the two eyes, and consequently in them the junction could not have the effects ascribed to it by the theory in question.*

* There is another mode of explaining this phœnomenon, which is some kind of modification of that just mentioned. It is founded in that theory which makes the choroides to be the seat of vision, and supposes the pia mater, of which the tunica choroides is a produc-

Some have imagined, that the sensations of touch alone give us the information of the unity of objects perceived by sight. This hypothesis, however, is sufficiently refuted by the consideration, that if the unity of objects, as made known by feeling, had once been established in the mind, no circumstances could render the sight double; for, at least, it does not appear how these causes, which are known to produce double vision, could tend to destroy this belief of unity of objects derived from the sense of touch.

Muschenbroek states, that the sense of sight and touch mutually assist each other. It may be observed here, that the touch is sometimes deceived as to the unity of objects, as in the familiar experiment of feeling a small globular body with two fingers' ends, when it will feel as if double.

Dr. Smith (whose theory is to be noticed afterwards), mentions this fact, and adds, that we have by experience of both senses compared together, learned to make their information consistent.

Dr. Smith thinks, that—"In the ordinary use of "our eyes, in which the pictures of an object are "constantly painted upon corresponding places of "the retinas, the predominant sense of feeling has "originally, and constantly informed us, that the

tion to unite just anterior to the supposed junction of the nerves, and to produce effects analogous.—*Le Cat. Traité des Sens*, p. 484.

It is quite unnecessary to make any particular remarks on this hypothesis, as the same objections which have been made to the former, apply to this also; and that it is besides connected with the exploded opinion of the choroides being the seat of vision.

"object is single. By this means, our idea of its "outward place is connected with both those sen- "sations, as is manifest by its appearing in two "places, when its pictures are not painted on cor- "responding places of the retinas, which is only "a direct consequence arising from our general "habit of seeing. And the reason why we direct "our eyes, so as to receive its pictures upon the "corresponding parts of the retinas, is this, that we "have got a habit of directing the optic axes to "the point in view; because the pictures falling "on the middle points of the retinas, are then dis- "tincter than if they fell on other places; and, "since the pictures of the whole object are equal "to one another, and are both inverted with re- "spect to the optic axes, it follows, that the pic- "tures of any collateral point are painted on cor- "responding points of the retinas."

This opinion evidently differs from the preceding, in this, that it supposes a connection between the perception of objects, in a particular manner, and the idea of their unity derived from the sense of touch, instead of a general belief, that the objects of vision are single, derived from the information of touch. It is, however, liable to the objections made to that theory, with the exception of that derived from the occasional double appearance of bodies. The sense of touch itself is occasionally in error as to the unity of bodies; besides this, it is inconceivable, that the appearances of objects should be so much influenced by touch, as that two should seem as one in consequence of any associations formed by that sense.

Dr. Wells adds some further objections to this theory, and shews that it is inconsistent with other conclusions which Dr. Smith had formed.

The theory of Dr. Reid is this, that objects appear single when they are depicted on corresponding parts of the retina of each eye, *i. e.* either on the centres, or parts equally distant from these, by an original property, which these parts possess, of representing objects single, independent of any association derived from touch. This theory is stated with great precision in the following passage of Dr. Gregory's Conspectus Med. Theoret. vol. i. p. 132.——

"Si axes binorum oculorum in idem punctum di-
"recti fuerint, imago ejus puncti, in centro utrius-
"que *retinæ* expressa, simplicem visum dat. Pono,
"res quotquot pari ab oculo distantia ad utrumque
"totust alis puncti siti sunt, simplices simul spectan-
"tur: quarum scilicet imagines super *retinam* utram-
"que depictæ, similem cum centro ejus comparatum
"situm habent. Centra igitur binarum retinarum
"et puncta in iis quæ similem quod ad centrum
"situm habent, supra, nempe vel infra vel dex-
"trorsum vel sinistrorsum consentire dicuntur vel
"simplicem visem dare. Res vero propius vel re-
"motius ab oculo positæ, quam punctum in quod
"axes oculorum conveniunt, simul cum illo spectari
"possunt earumque visus duplex est. Facile osten-
"ditur imagines earum rerum, partes retinæ utrius-
"que occupare, quæ dissimiliter quoad centrum po-
"nuntur: nempe in dextra parte alterius oculis in si-
"nistra alterius depingi. Partes igitur retinarum dis-
"similiter quod ad centra positæ non consentiunt,

" hoc est duplicem ejusdem rei cujus super utramque
" imago depicta fuerit, visum efficiunt."

This theory differs from Smith's also, as to what are meant by corresponding points, according to Dr. Wells's statement, although it may be doubted whether this author has not mistaken, in some measure, Dr. Reid's meaning.

Many others have given explanations of the phœnomenon in question, on principles somewhat resembling those of Dr. Reid and Dr. Smith.

Muschenbroek lays it down as a rule, that objects are seen single when their images fall on parts of the retina equally distant from the centre; but in a different direction; *i. e.* to the left in one eye, and the right on the other; if they fall on the same side, in both eyes, they appear double.

Willis states, contrary to the general opinion, that the insertion of the optic nerve coincides with the pole of the eye in man, and not in certain animals; and that in these there is no vision above the point of insertion, but that the sphere of vision is confined to a semicircle.—*De Anima Brutorum*, p. 78.

Dumas says—" L'image du chaque object se trace
" dans chacun des yeux, et neanmoins nous n'avons
" qu'une sensation simple, une seule idée parce-
" que les points de la rêtine ou les deux images se
" peignent sont en correspondance, en harmonie,
" et confondent leurs affections. Ainsi la sensation
" devient-elle double pour peu que la disposition
" des axes optiques soit altérée, et que par cette
" raison chacune des images cesse de tomber sur
" des positions correspondentes."—Tom. ii. p. 442.

This author does not, however, define what he means by corresponding points, and the expressions, harmony and correspondence of affections, are vague and indefinite. The only intelligible notion of this matter is, that the object is seen in the same place by both eyes, and therefore single when it is painted on certain parts of the retina, which, from some circumstances, may be considered similar to each other.

With regard to the remark, of which Dumas and some others, as Le Cat, make on this head, that we, in many cases, make use of only one eye, the difficulty is by no means diminished as to the vexata quæstio; for it cannot be denied that we often see objects single, when we yet look at them with both eyes.*

† Dr. Wells's theory is composed in the following propositions:—

I. Objects situated in the optic axis, do not appear to be in that line, but in the common axis.

II. Objects situated in the common axis, do not appear to be in that line, but in the axis of the eye, by which they are not seen.

III. Objects situated in any line, drawn through the mutual intersection of the optic axis to the visual base, do not appear to be in that line; but in

* The focal distance of both eyes is often not the same, and one is often stronger than the other. Haller affirms, that the right eye is generally made use of. Borelli contends, that the left is stronger, and always discerns objects more distinctly than the right.—*Journal des Savans, cited by Le Cat.*

Le Cat states, that he has ascertained this observation to hold true, with respect to many persons; but that in others, the two eyes are perfectly equal, and, in some, the right is stronger.

† Wells on single Vision with two Eyes, 8vo.

another drawn through the same intersection to a point in the visual base, distant half this base from the similar extremity of the former line, towards the left, if the object be seen by the right eye, but towards the right, if seen by the left eye.

A small object, as a pin, placed in the common axis, appears double, one image being apparent in each of the optic axes. If one eye is shut, the image, or visible object, on the opposite side disappears.

In applying these principles to the explanation of the phœnomenon in question, Dr. Wells proceeds thus:—

"If the question is concerning an object at the "concourse of the optic axes, I say it is seen single, "because its two similar appearances, in regard to "size, shape, and colour, are seen by both eyes in "one and the same direction; or, if you will, in "two directions, which coincide with each other "through their whole extent. It matters not whe-"ther the distance be truly or falsely estimated, "whether the object be thought to touch our eyes, "or be infinitely remote. When two similar ob-"jects are placed in the optic axes, one in each, at "equal distances from the eyes, they will then ap-"pear in the same place; and therefore, for the "same reason, that a truly single object, in the "concourse of the optic axes is not single. Here, "again, as the two visible directions coincide in "every point, it is not necessary that the united "appearance should be judged to be at any par-"ticular distance; that it should be referred, for "instance, to the concourse of the optic axes,

"when the two other theories of visible direction "are obliged to place it in opposition to the plainest "observations."

"Objects seen in the horopter, will be seen sin- "gle, because their apparent direction to the two "eyes will then completely coincide; and, for a con- "trary reason, those placed in any other part of "the plane of the optic axes will appear double." —p. 56, 7.*

Dr. Wells has added some very curious observations, relating to the connection between the position of the optic axes, and the refracting state of the eyes, and many conclusions with regard to the use and constructions of optical glasses. The muscular motions of the eyes are considered by him as the cause to which the appearance of objects in particular directions is to be referred; and, as he believes, from an original connection between the two circumstances.

The insertion of the optic nerve is not in the center of the eye, and consequently not at the termination of the optic axis, but more inwardly; *i. e.* towards the inner canthus. It has been generally imagined, since the experiments of Mariotte, that those parts of the images which fall on the spot where the nerve is inserted, are insensible to light, &c. The experiments in question are well known to consist in looking at three small objects, as pieces of paper placed on a wall, at a few feet distance, in a

* In favour of Dr. Wells's theory, it may be stated, that the author of the article Optics, in the Encyclopædia Britannica (known to be the late Professor Robison), asserts that it gives the best explanation yet published of the circumstances to which it relates.

particular direction, when the middle paper will disappear. The conclusion drawn by Mariotte from the result of the experiment was, that the retina was not the seat of vision, but that this office belonged to the choroid coat; this last coat being wanting at the spot where the nerve is inserted, and vision deficient; whereas the retina being itself an expansion of the nerve, may be considered as actually existing at this point. This opinion is now universally exploded, and the retina reinstated in its office, to which its origin from the nerve, and its delicacy of structure, fully establish its claim; the choroid being ascertained to be truly instrumental to vision, by absorbing the superfluous rays. With respect to the experiments in question, they have been mentioned by almost every modern writer on optics, and the fact of a particular spot of the eye being insensible, generally admitted, it may seem consequently presumptuous to call in question the truth of these circumstances; yet, the following considerations may, perhaps, be submitted to further inquiry, without incurring this charge.

If (as it seems to be well ascertained to be the case), only the termination of the optic axis is the seat of vision, at least of tolerably accurate perception of objects; is it not nugatory, or inconsistent, to lay down the position, that any particular part of the bottom of the eye is not sensible to light? If this statement is controverted, and accurate vision extended to every part of the retina, except that in question, viz. the insertion of the nerve, it seems not easy to explain, why there is not always a particular part of the sphere of vision, where there is

either a dark spot, or, at least, the want of visible appearances. It may indeed be replied, that the same objects which fall on the insensible part of one eye, do not fall on that in the other; but it is superfluous to say, that when only one eye is made use of in vision, this solution of the difficulty is not applicable. When any part of the retina is known to lose its power of sensation, as in the case of the appearance of muscæ volitantes, these dark spots are placed wherever the eye is directed, and following the motions of these organs.

It may be here mentioned, that the author of these pages has frequently made the experiment in question without success; for, on repeatedly looking at objects placed in the manner directed by Mariotte and others, he never could lose sight of either of them.

Dr. Darwin, in a paper in the Philosophical Transactions, giving an account of a very singular case of squinting, has made some curious speculations relating to this subject. He attributes the insensibility of the optic nerve, at its ingress into the eye, to a peculiar kind of vessel, which arises from this part, and extends through the vitreous humour upwards. He has observed this in calves' eyes. He adds, however, that he does not affirm that the human eye, either during infancy, or our riper years, is similar to that of a calf, nor have we sufficient opportunities to observe them. But I suspect, he says, this vessel may, after the growth of the animal, be totally obliterated; and that, in some instances, the optic nerve may even in this part become sensible to light. One instance I have seen

in a man who could never lose sight of the smallest object with either of his eyes. What foundation there is for these observations, is a question which belongs to anatomists to decide.

Does the whole extent of the retina serve the purposes of vision, or is this office confined to a particular spot of this membrane? The greater part of physiologists limit accurate vision to a small part, *i. e.* the central part, or the termination of the optic axis; admitting, however, that objects may be seen with less distinctness, whose objects fall on other parts of the retina.

There have been some varieties as to what is meant by distinct vision. Dr. Jurin makes a distinction between perfect and distinct vision, in which he has been followed by many others. Others, however, reject this distinction, and assert, that no vision takes place even in the common way, in which we perceive objects, except when they are painted on the abovementioned point of the retina; and this last opinion appearing to be the true one, it remains to be determined, how we seem to ourselves to perceive so great an extent of space, and such a variety of objects at once? Whence proceeds this illusion, it really being such? The answer given by many philosophers has been, that the duration of impressions on the retina, as takes place when we look at a luminous object, occurring in ordinary vision, although for a less time, occasions the co-existence of several of these minute perceptions, and that thus we obtain a view of many points of the surrounding objects at once. But the objections to this solution of the difficulty seems to be insurmountable. First, the spot which we perceive

when we have looked for some time at a candle, or other luminous body, is always projected on the object to which we afterwards direct our eyes, and the permanent impression conceived to take place in the above hypothesis, being formed in the same manner as the spot would likewise be posited on the next small object of perception; and this indeed is evident, a priori, for both the spot and the object, the present and past perception, depending on an affection of the same part of the retina, would be referred to the same external place. The consequence would be, that the whole of the object we were looking at, would appear to us under the form of several luminous spots one on the other. Secondly, the duration of the impression would depend on the intensity of light, and consequently the numbers of co-existent impressions, and therefore, necessarily, the field of vision would be affected by this cause. In a bright sunshine, therefore, we should have a wider range of vision than in a cloudy state of the atmosphere. This objection supposes the first difficulty to be got over. Thirdly, the duration of impressions does not appear, in the ordinary state of vision, to be sufficiently permanent to produce the effect in question. It is, therefore, not an organic affection which we are to consider as the cause of the phœnomenon in question, but some power of the mind itself. A celebrated philosopher refers it to memory, although there is no reference made to past time.* There is some power, or faculty of mind,

* Without memory, according to this author, we should have no idea of visible figure.—*Stewart's Elements of the Philosophy of the Human Mind.*

He likewise connects the proposition with another, that only one

by which these minute perceptions are connected together, so as to form the ideas of visible objects, as we imagine we behold them. The faculty, called conception, by some metaphysicians, comes nearest to the notion which we are led to entertain of this function; and many considerations tend to shew, that there is little difference, in many cases, between absent and present objects of sense, as to the belief of their reality. All the suggestions of the imagination, whilst actually existing in the mind, are probably believed to be real; the more vivid ones are undoubtedly so. With respect to real objects perceived by sight, their permanency, consistency with each other, and greater distinctness, produce a more continued and lasting persuasion, that their perceptions have an external cause present, to which they are to be referred, besides their agreement with the perceptions of the other senses.

The mode by which the eye accommodates itself to objects, at different distances, is another question. Kepler, the discoverer of the true mode and seat of vision, conceived that the globe of the eye was compressed by means of the action of its muscles.* But the most general opinion seems to have

idea can be present to the mind at one instant; but on this supposition it must be difficult to conceive how the mind acquires the notion of visible figure at all; for if one idea only can exist in the mind at any single instant, and one of the minute perceptions of the minimum visibile constitutes an idea, there can be only a succession of these perceptions without any connecting medium. Although only one sensation (or what may be called such), of sight is present to the mind at once, many phœnomena shew that more than one idea, in the usual sense of the term, is in general contained in the mind. That only one train of thought can take place at once is undeniable.

* Optica promota.—Dumas seems to admit this opinion, and Pro-

been, that some change was produced in the crystalline lens, either as to their position or figure. The ciliary processes have been supposed to move the lens backwards and forwards; but these processes are now found not to be muscular, according to the reports of the most accurate anatomists.—*See Zin. de Oculo.*

The crystalline lens has been stated to be itself muscular, and hence capable of altering its shape. This hypothesis, first brought forwards by the celebrated Dr. Pemberton, in a Thesis, printed at Leyden, 1727,* has lately been revived by Dr. Young, and new modified; but it does not seem to be consistent with the structure of this part, so far as yet ascertained.

The cornea has been supposed by others to become more or less convex; and, in a late volume of the Philosophical Transactions is an account of some experiments by Sir Henry Englefield and others, in which this was actually found to be the case. The eye of a person was viewed by a particular contrivance, while he was seeing a near object, and the cornea seen becoming more convex.

M. De la Hire long ago questioned the usual explanations of this subject, and attributed to the contractions and dilatations of the pupil, the whole of the changes which the eye undergoes in adapting to the perception of near or distant objects. M. Le

fessor Monro attributes an effect of this kind to the action of the orbicularis palpebrarum.—*Prælect. Anatom.*

* *Haller Disputationes Anatomicæ*, vol. vii.—A detail of the opinions relating to this subject may be found in Dr. Jurin's Essay, appended to Smith's Optics, vol. ii. on Distinct and Indistinct Vision.

Roy has defended the same hypothesis, and more particularly endeavoured to obviate the objections made to it by Dr. Porterfield. Haller seems to admit the truth of this opinion, denying in a great measure the existence of any power to the eye to accommodate itself to different distances, and supposing that the power which it actually has, to arise from the source just mentioned. M. Le Roy contends, that in order for an object to be distinctly seen, it is not necessary that the rays coming from it should be accurately brought to a focus on the retina,* although erroneously. †

There can be no doubt of the existence of this circumstance, *i. e.* the motions of the pupil; and, so far as it goes, must have the effect attributed to it. If we perforate a card or paper with a pin, we form a microscope, by means of which we can see objects much nearer than without such help, and consequently at a larger angle. This is, in fact, an artificial pupil.

The contractions and dilatations of the pupil are principally caused by the difference in the intensity of light, but also by the different distance of the objects veiwed. Thus Dr. Whytt remarks, that if a person comes from a dark room into one that is lighted, the pupil will contract; but that if then a pin, or small object, is placed before the eye, the pupil will contract still farther, in order to view it distinctly.

The motions of the iris, which are produced by the action of light, are solely to be attribu-

* Melanges de Physique et de Medecine, p. 109.

† Wells—passim.

ted to sympathy with the retina; for the iris is not influenced by light falling directly on it, according to the experiments of Fontana and Caldani.* As to those changes in the pupil, which are not produced by the action of light on the eye, but of which we only know, that they are instrumental to vision, their origin is very obscure; they have been supposed by some to be voluntary, at least so far as this, that the want of distinct vision occasions some efforts to obtain a clear view of objects. †

* A strong light enables us to see objects clearer than we should otherwise do, in many cases, by occasioning the pupil to contract. This may be shewn by a very easy experiment. A candle brought very near to the eye will be seen distinctly, when an object, not luminous, would appear totally confused. The light acts as a stimulus to the iris, and diminishes the aperture of the pupil. It is not to be denied, however, that objects strongly illuminated, appear more distinct on other accounts.

† See Note B.

MUSCULAR MOTION.

THE phœnomena of muscular motion are the following:——

Undulations, or irregular motions, in alternate directions, are perceived; the fibres are drawn from the centre to the extremities, and from the extremities to the centre, until at length the oscillations towards the centre predominate, and decide the direction in which the contraction of the whole muscular mass ensues.

This succession of oscillatory movements is very perceivable in feeble persons; it is rendered probable, however, that it always takes place, by the observations and experiments of Dr. Woollaston (Croonian Lect.) In stronger habits, the contractions follow each other with such rapidity, that they cannot be distinguished, and there consequently appears to be one uniform or permanent contraction. The fact is, therefore, directly opposite to appearances. In weak people, the oscillations take place slower than in others, and consequently become perceptible, and there is never a fixed state of contraction of the muscular fibres, except in spasm.

During the contraction the fibres become covered with folds, the extremities approach, and the

length of the muscle is diminished; the colour is not changed, it becomes thicker, but the whole bulk of the muscle does not appear to be either increased or diminished when it contracts. The degree to which the contraction can proceed is not ascertained: some have fixed the limit at the third of the whole length of the muscle; but this is by no means certain. Dilatation necessarily succeeds to the contraction. This is generally considered as simply a cessation of the latter state. Some have, however, contended that this, as well as contraction, is an effort of the living power.*

When a muscle is in what is called a state of relaxation, it is still more contracted than it would be if it had no vital principle, or if its elasticity or cohesion alone acted on its particles. This permanent degree of contraction is the *tone*, always existing in some degree; but greater or less in different circumstances. It is in consequence of this property, that a living muscle is not ruptured by a distending force, which would destroy the cohesion of its fibres, if dead; and a force being ap-

* "Le mouvement musculaire ne produit pas le seul phenomene "de contraction, il determine aussi la dilatation des fibres, qui "n'est pas une simple cessation de la premiere, mais un effort vrai-"ment actif, dont la réalité est bien certaine, à l'égard de la pupille, "du mamelon, des conduits lactiferes, de la verge, de la matrice, "et du cœur. Pechlin a observé que le cœur d'un animal vivent "peut si dilater encore, quoiqu'il soit retenu et comprimé fortement "par la main."—*Dumas*, tom. iii. p. 109. It is obvious here, that most of the phœnomena adduced by this ingenious physiologist in proof of his position, are only instances of the elongation of parts, in consequence of distention by means of fluids. In the case of the iris there is a different set of fibres for the contractions and dilatations.

plied, which tends to break it, the tendon is more easily ruptured than the muscular fibres, although the cohesive power is much greater in the former than in the latter. The contractions of the muscles themselves are, in some cases, sufficiently powerful to produce rupture of the tendons attached to them.

The power of contracting on the application of certain agents, is one of the most characteristic properties of living matter, and that which has of late, in a peculiar manner, attracted the attention of inquirers into the animal œconomy. Irritability is usually said to belong solely, or principally at least, to the muscular fibres.* The discovery of this property has been in general attributed to Haller. It must be admitted, that this celebrated physiologist and his disciples have much investigated this subject, and have called the attention of physiologists and pathologists in general to it. It is perhaps in a great measure in consequence of their enquiries, that medical theories have, within the last century, undergone a total revolution. The writings of Haller, on the subject of irritability, contributed

* It is true that some parts, besides the muscular fibres, possess a power of contracting independent of any mechanical cause—as the skin —the shrinking of the skin on the application of cold, in the cold fit of fever. In the skin of the scrotum this contractility is most conspicuous. After the removal of tumours, ascites, pregnancy, the skin, after it has been stretched, recovers its former dimensions. This is evidently different from mere elasticity, as the skin after death has not the same contractile power. Nevertheless it is also different from the irritability of the muscular fibres, not taking place with the same degree of regularity, nor depending on the same causes.

to overthrow the doctrines of the Boerhaavian school, in which he had himself been educated, and of which he was one of the most strenuous supporters and warmest admirers. Yet the merit claimed by him, and some of his followers, is perhaps, much exaggerated. Tissot asserts, in express terms, that the discovery of irritability is as important in physiology, as that of gravitation by Newton in general physics.—"As we owe physics "to England, we owe physiology to Switzerland." Many of the speculations of Haller are erroneous, or at least extremely questionable. He considers irritability as peculiar to the animal gluten, and as independent of nervous influence. The first of which positions is without proof, and the latter rendered doubtful by the enquiries of others. Neither is the discovery of irritability properly due to Haller; it was not, perhaps, entirely unknown to the ancients: among the moderns, Glisson has distinctly described it.*

The physiologists of the Hallerian school believe irritability and sensibility to be properties so distinct as to have nothing in common; that the parts of the animal body are not irritable in the same proportion as they are sensible; and some later enquirers have gone still further, and maintained that the exercise of the organs of sensation tends to diminish the irritability. Irritability, although nervous influence, is a sine quâ non with respect to it; does not appear to depend on the nerves in the same degree that sensibility does; nor

* See Note C.

does it exist in proportion to the multitude or size of the nerves in any particular organ. Irritability is very considerable in many animals which shew little signs of sensation. Yet there are also many considerations which may tend to approximate these two properties, and to shew their mutual dependance on each other to a certain degree. Irritability and sensibility seem both increased or diminished by the same circumstances. In warm climates, in the early periods of life, the female sex in the sanguineous temperament, and that temperament called *nervous** by some pathologists. Sensations have, in many cases, an evident effect in exciting the actions of the muscular fibres.†

Cold, applied externally, rouses from a state of syncope, produces contraction of the cutaneous vessels; hence stops hæmorrhages, &c. These effects can hardly be explained, except from the powerful sensation produced by cold. Mental exertion, or passions, are also followed, in many cases, by effects which shew a stimulating power, diseases of the inflammatory kind being the consequence.‡ Contraction of the muscular organs is generally attended with sensation, or a consciousness of the action which is taking place. This is not only the case in the voluntary actions, but often to a certain degree in those which are independent of

* Gregory Consp. Med. Theoret. sect. 921.

† "Quod sensum vero attinet, omnis plane sensus aliquid stimuli in "se habet, qualis, si modo satis validus fuerit, somnum vel arcere "vel jam presentem rumpere potest, vel varias demum corporis "partes ad motum aliquem ciere."—*Ibidem*, sect. 1802.

‡ Tissot de Valetudine Literat. p. 50.

the will; and probably the habit of not attending to these sensations, prevents them from being oftener perceived.

Irregular, or violent contraction of the muscular fibres, is attended with a painful sensation, as in cramp or tetanus. Certain sensations are necessarily connected with corresponding motions; as in many of those actions which have been called instinctive, or propensities; as coughing, voiding the urine or fæces. Peculiar sensations, not originally connected with motions, may, by habit, become associated with them, so as constantly to excite them when they are themselves produced. *

An application, which excites the animal fibres to contraction, is called a stimulus. A stimulus is not, however, to be considered as the cause of muscular motions, in the same sense as impulse is the cause of motions in inanimate matter. † "Sunt "occasiones duntaxat, nec adeo veræ causæ con- "tractionis: quem actioni irritamenti minime, "tanquam effectus respondeant, nec ab eodem inso- "lido vita destituto producantur."—*Gaub. Pathology*, sect. 171.

The effect of stimuli is modified by a great variety of circumstances—age, sex, temperament, mode of life, idiosyncracy, besides particular states which are merely temporary.

Distention is one of the most universal causes of muscular contraction; and all the parts of the body in which contractions ever take place at all, may be

* See Note C.

† Essays, Philosophical and Literary, by Dr. Gregory.

excited by this cause, although, with respect to most, there are specific or appropriate stimuli, by which their actions, in the ordinary states of the system are produced. Thus the blood is the specific stimulus to the heart and arteries, the urine to the urinary bladder, the food to the stomach and intestines, &c. The action excited by a stimulus does not always cease on its removal. Thus vomiting continues after the substance which originally excited it is entirely thrown out of the stomach; and the heart of an animal just killed continues its contractions and dilatations, although emptied of its blood. In like manner the contractions of the uterus, and the parts in concert with it, continue after parturition, and produce the after-pains.

A stimulus having been applied to a particular part, if its application is repeated within a short interval, the effect which results will be less than at the first application, and still less on a subsequent trial. Yet there are facts apparently contradictory to this general law. When a part has been often acted on by a stimulus of any kind, it acquires a facility of performing the action which has been excited in it; and even a less powerful application will be sufficient to produce it. In this case, so far as a passive habit is concerned, the effect of the stimulus may possibly be diminished by repetition; but the greater proneness to, and facility of performing the particular action, which is required by its having repeatedly taken place, counteracts this effect, and occasions the result to be what is stated. Much, however, seems to depend on the effect of the first application. If this has been powerful,

the quantity or force of the stimulus may be often diminished on subsequent applications, without any diminution of the effects. Thus aloa, or any other purgative, exhibited so as to produce copious discharges by the intestines. After a few repetitions, the dose may be lessened, the same evacuation still taking place.* On the contrary, if the first exhibition proved inert, a subsequent one, even to a greater extent, may fail of its effects. Dr. Fordyce observes, that Peruvian bark, exhibited in the cure of intermittents, if given at first, in such a dose, or in such states of the disease as not to act, may be exhibited afterwards, even in larger quantities without benefit. If the stimulus is increased beyond a certain degree, the effect which results is not in proportion; but is, perhaps, not greater than if a much less stimulus was applied. The doses of medicine are thus limited within certain bounds; but it is often the case, that although a stimulus no longer produces its specific effects, or that peculiar kind of action which usually results from it, actions of a different kind may be occasioned, or perhaps merely pain. After an organ has been repeatedly acted on by a stimulus of a peculiar kind, so that it has *given out,* if the expression may be allowed, all the exertion which that particular stimulus can call forth, another kind of stimulus will produce action in it. A muscle, separated from the body, retains its irritability for a certain time. Punctures or villications may excite contractions in it. After this has been done repeatedly, the muscle no longer obeys this mechanical stimulus; yet

* Zoonom. sect. xii. 3. 1.—Fordyce's Elements, p. 117.

chemical stimuli, or those which are possessed of a certain degree of acrimony, if applied at this period, may renew the contractions; and after these, in their turn, have become inert, electricity, or that peculiar modification of it, galvanism, may again call the contractile power of the fibres into action.

Certain muscles are commonly said to be voluntary, or to be excited to action by the influence of the will, as others are by external stimuli. A totally different view of this subject, as is well known, has been taken by certain philosophers. According to these, the will is not the cause of the motions of our limbs; but the consequence, or rather a concomitant effect—mechanical causes, determine the motions, and also the will; so that we suppose the will is the cause of the motions, because we are conscious of our volitions, and do not perceive the real causes which occasion the actions of our organs.—

"Concipe jam si placet, lapidem dum moveri pergit, cogitare, et scire se quantum potest conari ut moveri pergat. Hic sane lapis quandoquidem sui tantum conatus est conscius et minime indifferens, se liberrimum esse, et nulla alia de causa in motu perseverare credet quam quia vult. Atque hæc humana illa libertas est, quam omnes se habere jactant; et quæ in hoc solo consistit quod "homines sui appetitas sint conscii et causarum "a quib moventur ignari."—*Spinosa in Epist. cited by Gravesende, Introduct. ad Philosophiam,* p. 52.*

* See Note D.

The system of Dr. Hartley on this subject has many partisans. According to this author, all the muscular motions are originally *automatic,* and volition is generated by the constant association of certain of these motions with pleasurable sensations. The reverse of this process he supposes to take place with respect to the habitual actions; these again become automatic, or there is a transition of voluntary actions into automatic. Dr. Darwin has adopted a system very similar to this.

Whatever side of the question is taken, difficulties present themselves; but, on the whole, the common opinion seems to be attended with least. That the mode in which motion is produced in the organs of the living body, by the agency of the will, is inexplicable, will not appear surprising, when it is considered, that the communication of motion by impulse is a phœnomenon which has never yet been accounted for, and which is only known from experience. It is impossible to conceive that the conviction which we have of possessing a power over the motions of our limbs should be stronger than it is. Much difficulty has arisen from the case of the habitual actions, or of those motions which take place with a greater degree of rapidity than usual, in the muscles usually subjected to the will. After these motions have been performed, no remembrance remains in the mind of any volition having accompanied them. It is, however, by no means absurd to suppose that the will is notwithstanding concerned in their production. It is not necessary to recur to the exploded idea of the soul thinking or willing without conscious-

ness, according to the hypothesis of Stahl and his followers. These acts of the will probably escape from the memory the moment after they have taken place. There are still other motions, of the nature of which more doubt may be entertained, and which seem to be intermediate between the voluntary and involuntary. In these, nevertheless, although there is no design to which they are directed as to an end, which is the case in the motions which are strictly voluntary; yet that state of mind which accompanies, or immediately precedes the voluntary motions, may take place, although it is determined by a peculiar sensation, instead of a desire produced by deliberation.—

"Hæc ratiocinatio possit extendi ad certos mo-
"tus qui in nobis nec voluntarii nec naturales sunt
"medii vero cujusdam generis, naturales eos haud
"nuncupo si quidem raro nostro fiunt in corpori
"et solum modo certis occasionibus parum crebris.
"Ex hoc numero esti ste quasi tremor quem in nobis
"produit sonus explosi tormenti vel gravioris to-
"nitru fragor ex hoc horror qui aspectum sequi-
"tur præcipities in quo nos versari de improviso
"comparimus. Etenim motus istos saltem præcedit
"cognitio et sensatio et si dubium sit illarum istos
"esse effectum, incertum est saltem an istœc cog-
"nitis et ista sensatio ad istos suum non conferant
"symbolum."—*Novæ Difficultates a Peripatetico propositæ Auctori itineris per Mundum Cartesii circa Cognitionem Brutorum*, p. 11.

Something of the same kind seems to be the case in that propensity to imitation which is so remarkable, and which, on many occasions, produces such

singular effects. Thus, when we see a person losing his balance, and inclining his body to one side, by actions rapid and apparently involuntary, we move our own bodies in the same direction. This tendency has, in some instances, existed in a very uncommon degree, of which the following is an instance.—

" Ce pantomime singulier portait l'imitation jus-
" qu'a rendre scrupuleusement les plus legers mouve-
" ments des yeux, des levres, des mains, des
" pieds, &c. Il se couvrait et decouvrait la tête,
" suivant qu'il la voyoit faire aux autres avec une
" liberté et une facilité surprenante. Lorsqu'on
" essayait de lui ôter l'usage d'une main, tandis
" qu'il gesticuloit de l'autre, il se debattait avec
" des efforts extraordinaires, et le raison qu'il en
" donnoit c'est qu'il y etoit force par la douleur
" qu'il resentoit au cerveau et au cœur. Enfin ce
" pauvre homme en consequence de son incommo-
" dité, n'alloit jamais dans les rues que les yeux
" bandés et lorsqu'il lui arrivoit de s'entretenir avec
" ses amis, c'etoit en observent la precaution de
" leur tourner le dos."—*Fouquet Dict. Encyclopéd. l.* 15, *Art. Sensibilité.*

SLEEP.

IT is a law of the animal œconomy, that all actions which take place are limited as to their duration. A muscle excited to contraction by a stimulus, or by the power of the will, after a short space, again relaxes. Contraction may, however, again be produced in it almost immediately; but this alteration of contractions and relaxations can only continue for a certain length of time, and the necessity occurs of a permanent state of quiescence. The case is somewhat different in the vital motions. The heart and arteries, from the beginning of life in the embryo, to the hour of death (if not interrupted by disease,) continue their alternate contractions and relaxations. Yet these organs are not entirely exempt from the abovementioned law. The diastole is a state of cessation of action, which, short as it is, serves to recruit the powers of the heart and arteries. Moreover, if the action of the heart is more vigorous than usual, from any cause, a total quiescence often is the consequence for a certain period, and syncope or asphyxia ensues; possibly it is in consequence of a similar principle, that the increased action of the vessels in inflammation, when

excession is followed by a total cessation of action, and the death of the part. In the whole system a violent exertion of body or mind, excessive muscular efforts, the excitement of powerful emotions of mind, are followed by syncope, or even by death. Nor is the exhaustion which follows any exertion confined to the particular organ which has been in action, if that action has been excessive, for the whole system may be affected in consequence. Exertion of the mental powers tends also to produce bodily fatigue, even more, perhaps, than exertion of the organs of the body; and, on the contrary, after violent bodily exercise, the intellectual powers are rendered inert. It would appear from these considerations, that all the functions of the living system, both mental and bodily, arise from one common principle, whatever may be the nature of it, contrary to the suppositions of many modern theorists.

In perfect sleep, both the body and mind appear to be in a state of quiescence, except in those particulars where an exertion is necessary to life; and these functions go on with less vigour than in a state of watchfulness; but this may be only a secondary effect. The influence of the state of mind on the actions of the heart and arteries, is well known. Emotions, or passions in general, accelerate these actions, and even perceptions, unattended with any concomitant passion. During sleep, unattended with dreaming, the agency of these causes is necessarily excluded, and the pulse may therefore be supposed to fall below its natural standard, as to frequency

or force. The same circumstances may contribute to render respiration slower; besides, from the connexion which in general subsists between the two functions of circulation and respiration, a diminution of the former will be attended with a corresponding state of the latter. Another consideration is, that the action of the muscles of respiration is in part voluntary, and, therefore, when volition is suspended, will go on with less energy.*

These voluntary exertions are not necessary to carry on respiration in the ordinary states of the system; but in the cases abovementioned of great debility, when the general powers of the system are much diminished. The concurrence of volition with the usual stimuli to action, becomes essential to the continuance of this function. Hence patients awake soon after sleep has commenced with palpitation, intermittent pulse, and especially disordered respiration, and endeavour to prevent the recurrence of sleep from the apprehension of the abovementioned effects. Perhaps the "subita excitatio "somno in hydrothorax," is to be ascribed in part to an analogous cause, and not merely to the horizontal posture increasing the mechanical impediment to the descent of the diaphragm.

All the sensations are supposed to be diminished in sleep, except the cutaneous discharge; and this

* "Thus, in sleep, where there is great debility or fatigue, as the "pulse intermits, and the respiration is previously effected. This "seems to arise from the want of some voluntary efforts to facilitate "respiration, as when awake."—*Zoonom. Art. Somnus Interruptus*, Chap. i. 12, 14.

is, in all probability, to be ascribed to the warmer covering used in sleep. The heat of the system seems diminished, or, at least, a sensation of coldness is felt on awaking from sleep, when the body has been clothed only in the usual manner.

In sleep, the mind is often in action, either from its being imperfect (and hence dreaming occurs most frequently at the commencement of, and just before the cessation of sleep), or from some affection of the body, as an uneasy sensation. The great difficulty in ascertaining the precise state of the mind in dreaming, results from the imperfect recollection of what passes in that state. The imagination seems to be more active than when awake. The power of the will, both over the ideas of the mind, and over the motions of the limbs seem, in a great measure suspended, and this suspension of volition has by some been considered as constituting the essential part of sleep.

The proximate cause of sleep has been the subject of many speculations, none of which are at all satisfactory, or even consistent with fact. Compression of the brain has been imagined to be the cause; but it cannot be shewn that this circumstance actually takes place in ordinary cases of sleep; and when it does exist, it produces a state of stupor very different from healthy sleep. Exhaustion of the nervous fluid is another hypothesis; but, besides the obvious objection from the existence of this fluid being merely gratuitous, sleep often does not take place when the exhaustion of the nervous fluid, supposing this to be produced by the exercise of the organs of sense and motion, must have

occurred; and, on the contrary, sleep may come on when the nerves ought still to abound with this fluid.*

Whatever tends to exhaust the powers of the system in general, induces sleep. Fatigue of body or mind; in some cases depressing passions. Cold has been said to have this effect; but this is doubtful. The slighter degrees of cold prevent sleep by the uneasy sensation excited. Intense cold induces stupor, which terminates in death. But this does not seem to be universally the case. In the account of some persons who perished in consequence of long continued exposure to cold, published by Dr. Currie, coma is not stated to have occurred.

Whatever induces inattention to external objects brings on sleep. Rocking children in cradles seems to occasion sleep, by rendering the perception of visible objects indistinct, so that the attention is not attracted by them. Uniform sounds act in the same manner, by removing the attention from the external impressions, and afterwards ceasing to attract it themselves from their becoming familiar. On the removal of an uneasy sensation, sleep is apt to occur in the intervals of violent pain; as between labour pains. This may be from two causes: first, increased excitement is followed by collapse; secondly, the attention has been absorbed by the powerful sensation of pain. On removing this, the perception of external objects are too weak to attract the attention; and sleep succeeds, as in other cases, when this circumstance occurs.

* See Note E.

During the continuance of violent pain, although inattention to external objects is necessarily the consequence of it, yet the sensation of pain is sufficient to prevent the access of sleep; but on the cesssation of the pain, the inattention to external objects still, in a great measure continuing (for after being accustomed for a time to stronger impressions, weaker ones lose their effect in arresting the attention), sleep ensues.

CIRCULATORY SYSTEM.

THE blood, returned from all the parts of the body, by the venous system, passes from the vena cava into the right auricle of the heart. This auricle contracting, impels its contents into the right ventricle; from thence, they are propelled into the pulmonary artery, and distributed through its ramifications in the lungs, returning by the pulmonary veins, the blood is sent to the left auricle; from thence, into the ventricle of the same side and the aorta, and by this means the whole arterial system.

Both auricles, and both ventricles, contract simultaneously, and consequently—

The contractions of the auricles take place during the dilatation of the ventricles, and vice versa.

The aorta and pulmonary artery have their contractions and dilatations opposite to those of the ventricles, and consequently synchronous with those of the auricles.

The heart has been usually considered the most irritable of all muscular structures. It is excited to contraction not only by blood, but air; and almost all those agents which excite contractions in any

muscular parts. The blood alone, however, seems capable of producing contractions in the usual and regular manner. This organ even continues its contractions and dilatations for a considerable time after it is separated from the body. This was remarked by the ancients, and must necessarily have led to the idea of something like irritability of later physiologists. *

It was believed, till about the middle of the last century, that the heart was the sole agent which propelled the mass of blood throughout the body. The blood vessels were conceived to be mere inert tubes, or to have no other powers of contraction than what resulted from the elasticity of their coats It is now generally admitted, that both arteries and veins possess a muscular power, although no red muscular fibres can be discerned in them. The unequal celerity with which the circulation takes place, in some cases, in different parts of the system; the phenomena of local inflammation, and experiments instituted for this purpose, demonstrate the irritability and contractile power of the sanguiferous vessels. Interposed between the arterial and venous systems are the capillaries, which, in some parts, are so minute as not to admit any of the colouring parts of the blood. This certainly cannot be the case in all parts of the system, nor even in all the vessels of any single organ; for, on this supposition, it is obvious that the red particles could never get into the venous system at all. It must be observed also, that capillary

* "Vidimus cum cor alicujus animalis evulsum est quod igne "quasi celeritate micaret."—*Cicero de Nat. Deor.* lib. ii.

vessels, although invisible, may yet contain the colouring particles of the blood; for it is ascertained by microscopical observation, that a single particle is transparent. A few accumulated give a brown or yellow colour, and it requires a considerable number to form the red colour of blood. The vessels of transparent membranes, as the adnata of the eye, may therefore possibly admit these particles, although not in sufficient number to give a red colour, unless when preternaturally distended, or having more than their usual quantity, as in cases of inflammation.*

In some organs, as the spleen and corpora cavernosa penis, a different structure obtains, or cells are interposed, between which the mouths of the smaller branches, or arteries, pour their contents, which are thence conveyed by the corresponding veins which arise from those cells.

The hypotheses which have been invented to explain the action of the heart and arteries are innumerable. The innate heat of the ancients, which, producing a rarefaction of the blood, occasioned its expulsion from the ventricles into the arteries. The ferments of Des Cartes were imagined to have a similar effect; he supposed that the blood passed into the ventricles at the time of their dilatation, in consequence of the rarefaction of this fluid.

Willis, attributing the actions of the heart, like those of all the other muscles to the nervous influence, supposes that the cardiac nerves are derived

* Spallanzani on the Circulation—Senac Traité du Cœur.
See Note F.

solely from the cerebellum, and hence the involuntary nature of the action of this organ.

Mayow, Lancisi, and others, imagined that the nervous plexuses had the effect of removing the influence of the will over the motions of the heart, by placing obstacles, which could not be overcome by it. * The latter physiologist added to these assumptions another equally gratuitous, of a certain stimulant principle in the blood, produced by heat and volatility.

Lower considered the heart and brain as antagonist machines, which had a mutual correspondence and influence; a principle, which however insufficient as a complete explanation of the matter in hand, has undoubtedly a real existence. The dependence of the heart and brain on each other, however it may be explained, being among the most unquestionable facts relating to the animal œconomy.

Borelli sought for the motions of the heart in an effervescence of the animal spirits with the blood.

Stahl referred the motions of this organ, like all the other functions, to the soul acting according to design and intelligence.

Boerhaave, taking for granted that the nerves were the source from whence the contractions of the heart were derived, imagined an alternate compression and cessation of pressure of the nerves which pass to this organ, whence they were rendered inert, and again recovered their powers.

* Similar to this is the Theory of Johnston respecting the use of the ganglions of the nerves.

And by this means the muscles composing the heart were by turns paralytic, and again capable of action. Hence the systole and diastole, which were mutually causes of each other.

Senac, in his very admirable work on the heart, has adopted an hypothesis somewhat analogous to this. He observes, that the natural state of the muscles is contraction, when their antagonists are removed. The heart has no antagonist. It will therefore be contracted from the nature of muscular structures. In this state of things, the blood coming into the ventricle, will press against the orifice, where the auricle opens into it, and consequently compress the cardiac nerves. The ventricle will thus become paralytic and relax, and the blood will have room to enter. When the auricles are empty, the compression will cease in the nerves, and the heart will recover its power of contracting.

Of late, all these theories have given way to the irritability of Haller and his school;* that property of the animal body, by which muscular structures contract, on the application of stimuli, and which the heart was supposed to possess in a greater degree than any other muscle; we may here revert to the remarks formerly made on irritability in general. The heart most unquestionably differs from the voluntary muscles as to its manner of contracting, &c. but whether it is from any original difference in the structure and properties, or merely of the exciting causes, is not sufficiently ascertained. The exciting cause of its contractions is continually present

* See Note G.

and applied to it. It may not, therefore, be the case, that the heart is more *irritable* than the other muscles, but that it is more *irritated*. But then it may be objected that the irritability would thus become diminished or extinct, unless there was something peculiar in the organ, in consequence of this constant exertion. To a certain degree, this is actually the case; the heart becomes less irritable as life advances; hence the slowness of circulation in old age, compared with that in infancy and youth. The influence of the nerves on this organ is a matter of dispute. The cardiac nerves are small in comparison with the size of the organ, yet they are very numerous. Soemmering has asserted that the muscular substance of the heart has no nerves, but that they are all distributed to the coronary arteries. An injury done to the nerves, does nevertheless ultimately impede or put a stop to the action of this organ, besides the proofs which might be drawn from the effects of passions of the mind, in producing syncope or palpitation. Connected with this, is the question as to the sensibility of the heart. This is denied by Haller. But here there is great uncertainty. Experiments on living animals, to which Haller principally trusted, are extremely fallacious. Sensibility, besides, has something specific: it requires peculiar agents to excite it, and it would be fallacious to conclude, that because, with one kind of external application, and under certain circumstances, an organ shewed no sign of sensation, that therefore it was destitute of this property.

It does not appear necessary to have recourse to any other supposition than the stimulus of disten-

tion acting as an exciting cause. This has been questioned, because the different parts of which the heart is composed, act differently with the same irritation applied. Thus Metzger found, that the auricles and ventricles being irritated at the same time, the one contracted whilst the others dilated. Dumas, on this ground, accuses Haller of prejudice, because he did not recognize a difficulty in the way of his own peculiar opinions. But there seems to be no foundation for this charge. The exciting cause should be expected to give rise to those actions which are natural to the part excited, and which result from its structure and usual functions.

Haller mentions, as a cause of cessation of the action of the heart and death, the want of its usual stimulus the blood; which, although questioned by his great opponent De Haen, (Ratio Medendi, vol. iii. p. 89), has been confirmed by the testimony of later writers. Obstruction to the passage through the lungs, or a deficiency of blood in the system in general, producing this effect.

A difficulty is made by Dumas, to the system of Haller, that it does not explain how relaxation follows contraction. For, he objects the habitual irritation which the blood gives to the heart, has only the known acknowledged effort of contracting it; and there is always a quantity of blood in the ventricles during the diastole which has not been expelled by the contraction. This fact has been confirmed by Weitbrecht, Senac, and Spallanzani. Haller endeavours to deny it; but there is in reality no ground for considering it as any objec-

tion to distention from blood being the cause of contraction of the heart. The contraction of this viscous, like that of the other muscles, is only temporary; relaxation necessarily follows spontaneously after a certain time, although the exciting cause is still applied.

The contraction of the heart, after it is removed from the body, and emptied of its blood, has likewise been brought by this author as another objection;—but although the blood, or the distention which it produces, may be the proper and natural stimulus; other substances may have some effect in producing motions of this organ, or even the contractions may continue after the removal of all stimulating agents. These actions are, however, irregular and anomalous, the usual and natural motions are only excited by the distention from blood.

The motions of the arteries were attributed by the ancients to a *pulsific faculty*; this view of the matter, however it may appear to present to the mind merely a statement of a fact, without any explanation, is in reality a juster mode of expression than many of the modern theories. It does admit the existence of a power of motion, inherent in the vessels themselves; whereas Harvey, and many of his followers, have considered the pulsations of the arteries as merely the result of the impulse of the blood into them by the action of the heart.

The existence of the muscular powers of the arteries was most distinctly known to, and stated by Willis.—"Enim vero ex observatione anatomica "plane constat arteriæ cujusque tunicam mediam "esse plane muscularem atque febris carneis (cu-

"jusmodi sunt ventriculi, intestinorum, et quorum-
"dam viscerum), per totum constare. Quæ fibræ
"annulares densa velut capillamentorum serie ar-
"teriæ ductum sive, tubum ubique cingentes
"procul dubio systoles suas et proprias diastoles
"æque ac cor ipsum obtinent. Qua propter impri-
"mis dum fibræ cardiacæ et dein hæ arteriosæ
"successive et seriatim contrahantur, necesse erit
"sanguinem a meta una ad alteram rapidissime
"propelli. Quare haud prorsus de nihilo quod me-
"dici quidam etiam arteriis facultatem pulsificam
"attribuerunt, quippe multum improbabile est,
"mero cordis tanquam emboli impulsu, sanguinis
"circuitum peragi."—*De Med. Operat.* p. 104. *

It appears, however, that the observations of Willis were entirely overlooked by contemporary or succeeding physiologists, for the discovery is generally attributed to Verschuir. It does not seem that Willis had made any experiments in confirmation of his opinion, although he advances very strong reasons in favour of it. Indeed the considerations stated by him are of more real weight than experiments on irritability, often fallacious and uncertain.

Haller, and the greater part of his followers, have refused to recognize any contractile power in the vessels dependant on life, and distinct from elasticity. The experiments of Haller were falla-

* The same has since been fully proved by the experiments and observations of Verschuir de Arteriarum et Venarum Vi Irritabili, 1766, Gotting.—Dennison Dissertatio Inauguralis de Vasorum Irritabilitate, Edin. 1773.—Fordyce's Elements, part 1.

cious, because not repeated under sufficient variety of circumstances. It is, however, to be admitted, that there is something peculiar in the irritability of the muscular fibres of the blood vessels. Dumas thus observes:—" Les vaisseaux ont leur irritabilité speci-
" fique, qui n'est mise en jeu que par des stimulus ap-
" propriés, et qui n'étant celles point des muscles, ne
" peut suivre les loix de l'irratabilité musculaire."

Some late writers on physiology have considered the heart as the sole organ concerned in the circulation.—*Bichat Anatomie Générale.—Spallanzani on the Circulation.*

Haller's statement is inconsistent.—" Nervi pas-
" sim longe per arteriarum superficiem descendant
" et in cellulosa tela evanescunt exemplo carotidis
" internæ, externæ, arcus aortæ. An non inde vis
" aliqua contractilis, spartica, diversa a simplico
" elatere? Nonne aliquid fibres arguant, et animi
" diliquia? Paralysis cum atrophia? Adfectus animi?
" Sed arteria absque sensu est et absque conspicua
" irritabilitate, et si a venenis constringitur, habet
" id cum mortua cute commune."—*Prim. Lin.* sect. xxxii. Is it not singular that this celebrated author, after enumerating the most forcible reasons for the power of contracting, in consequence of life existing in the blood vessels, should conclude by denying the principle in question. The increase of this contractile power in diseases, when the elasticity remains the same in inflammation, hæmorrhage, &c. Thus Pinel gives the name of Angiotenique to these affections.

The blood circulates through the very minute ramifications of vessels solely by their muscular con-

tractions, for the influence of the heart does not extend to them.—*Proschaska. Controv. Quæst. Physiol. quæ Vires Cordis, &c. Vienna,* 1778.

The pulsation of arteries, at different parts of the body, are not always synchronous. The application of topical stimuli, heat, friction, &c. excite a more quick contraction of the smaller vessels of any part—topical inflammation.

The influence of the passions of the mind on the vascular system in the instances of blushing, erections, paleness, stopping hæmorrhage, secretions, bile, urine, tears, serves to shew the existence of this principle in the vascular system.

After the circulation has ceased in the heart and larger vessels, the blood still continues to move in the capillaries.

Haller remarks, after having emptied the heart, and tied the larger vessels, the smaller ones still continue the circulation, nearly as in the usual manner. He even saw different modes of irritation renew the motions after they had ceased.

Spallanzani has some similar observations. It is not easy to conceive how they could shut their eyes against such palpable proofs of the existence of the property in question in the sanguiferous vessels.

The elasticity of the arteries is opposed to their muscular power, and acts in a contrary direction. When the arteries are in their greatest state of dilatation, they are of a larger calibre than they would be of, if left to the action of their elasticity alone: after death they become larger. The impulse of the blood into these vessels is not the cause of their dilatation by forcing them open; but,

on the contrary, it follows this dilatation. The arteries relax, and thus give room for the blood to enter them. This influx continues till they are distended to a certain degree; the distention then acts as a stimulus, and occasions them to contract. The blood is thus thrown again out of them; the contraction ceasing spontaneously, the elasticity restores the vessels to their former shape and size, and the blood again enters them.

It is to be observed, that the contraction of the muscular fibres never totally ceases in the diastole; the *tone* still continues, a certain permanent state of contraction, which, although it varies according to the different states of the animal economy, does not alternate with a state of relaxation, like the other muscular actions.

An experiment, related by Galen, will serve to shew that the pulsations are to be attributed to the muscular actions, and not to the impulse of the blood.—He introduced into an artery a tube longitudinally, after having first made a ligature above the part. On relaxing the ligature, he observed that the pulsations took place as usual in the whole length of the artery. But on pressing strongly the coats of the vessel which inclosed the tube against it, the pulsations ceased in that portion of the artery which was beyond the tube, although the blood continued to flow through it. *

The elasticity is greatest in the larger arteries—the muscular powers in the smaller ramifications.

* This experiment has been repeated by several modern anatomists, and in general with the result above stated.—*See Dumas*, tom. ii. p. 206 and 348. An experiment, the inverse of it, has been made by

We may here mention the researches of Sir Clifton Wintringham respecting the vascular system. The density of the coats of arteries to veins is greater in old animals than in young, and consequently the capacity of these vessels in the contrary proportion.*

The results drawn from these experiments, by the ingenious contriver of them, and by some others, were far too numerous and extensive; for, like all merely mechanical conditions, their influence of the circumstances just stated, must be received with great caution; yet they are in reality important, and when taken in conjunction with the living powers, lead to very interesting conclusions. It was on these experiments that Dr. Cullen principally founded his Theory of the Hæmorrhage, which, in the opinion of his distinguished successor in the chair of practical medicine, is one of the most beautiful parts of his system.†

Lamure. He found that the portion of an artery, inclosed between two ligatures, continued to pulsate, although not containing blood.

This fact, however, has been questioned by others.—See Walæus De Motu Chyli apud *Bartholini Anatom.* p. 1—7.

* See Hunter on the Blood,—on the subject of the Elasticity and Muscular Action of the Arteries.

† See Cullen's First Lines, and Institutions of Medicine,—Webster Tentamen Inaug. de Vasorum Sanguiferorum Equilibrio.

RESPIRATION.

RESPIRATION consists of two distinct parts—inspiration and expiration. In the former, the cavity of the thorax is dilated by the elevation of the ribs, and the descent of the diaphragm, the lungs following the dilatation of the parielis. If the chest expand, a vacuum is formed in them, and the air rushes in. At the time of expiration, the ribs are depressed, the diaphragm ascends, the capacity of the chest is diminished, and the lungs being contracted, expel the air from their cavities.

Inspiration is effected by means of certain muscles which raise the ribs, and the diaphragm, itself muscular, contracting, descends.

In expiration, the muscles relaxing, allow the elasticity of the cartilages of the ribs to act so as to bring back the parts to their former position, and the diaphragm also relaxing its central parts ascend into the cavity of the chest.

(The lungs themselves are now generally admitted to be entirely passive in respiration.)

The number of respirations in a minute is about eighteen. It varies in disease, so as to be sometimes nearly double that number.

The purpose of respiration is the subjecting the blood to the action of the atmospheric air. The researches of modern chemists have shewn, that somewhat less than a third of the constituent parts of the atmosphere is that which alone is capable of supporting animal life. This is either absorbed by the blood in the pulmonary vessels, or, as later investigations appear to have evinced, a certain noxious matter, separated from the blood, is combined with it, and the compound, thus formed, is expelled.

Another circumstance to be remarked is, the change of colour which the blood undergoes, from a dark to a florid red. The manner in which this is effected is, however, not sufficiently ascertained.

The function of respiration, taken in every point of view, is a subject attended with considerable difficulties. The chemical changes which the blood undergoes in the lungs, by the action of the air on it, although they have received great elucidation from the researches of modern chemists, are still involved in some degree of obscurity. The nature of the muscular actions, by which the cavity of the chest is dilated and contracted, is also uncertain. I do not allude to the particular muscles concerned in the motions of the ribs and sternum, the direction in which these fibres contract, or the precise office of each muscle; but as to the cause exciting these actions: how far they are dependent on, or subject to, the influence of volition, particularly how respiration first takes place after birth.

The necessity of respiration attracted attention, and gave rise to some sort of theory or attempt at an explanation among the ancients.—" Ob duo po-

"tissimum vivunt animalia, escam videlicet et "spiritum. Ex his multo magis vitæ conducit spi- "ratio. Hanc enim si quispiam supprimat, non "diu feret incolumis: sed pertinus interibit. Hu- "jus instrumenta multa parata sunt. Initium sunt "nares, via est arteria, locus continens pulmo. "Pectus autem pulmonis est vallum et conceptacu- "lum. Verum cætera ut instrumenta solum ani- "mali subserviunt, pulmo vero attrahendi causam "in se continet. Namque in ipso medio calidum "viscus sedet cor, vitæ spirandique principium. "Id pulmoni quoque attrahendi frigidi aeris cu- "piditatem injecit si quidem ipsum incendit: ve- "rum cor est quod attrahit. In primis igitur si "cor affectum est, non diuturna est mortis dilatio. "Si pulmo male habet, pusillam quidem ob causam "difficulter spirat, male vitam agit, mors tadrissi- "ma advenit, si quis medelam adhibet."—*Aretæus*, lib. ii. cap. i.—*Junio Paulo Crasso Interp.*

Most of the ancients, however, attributed the motions which take place in respiration to the dilatation of the pulmonary artery, by the impulsive force of the heart, without attending to the obvious objection that the pulsations of the heart and respiration do not correspond; three or four pulsations taking place during the time of one respiration, or an inspiration and expiration.

Descartes imagined that the dilatation of the chest pushed forwards that portion of air which was nearest to it, and this the next, till, at length, by a sort of circular revolution, the air was precipitated into the cavity of the chest. Others, as

Willis, contended that the air taken into the chest was dilated by the diminished pressure. Hence it became specifically lighter than the external air, which accordingly rushed in. But in both these theories the dilatation and contraction of the chest are presupposed, and no explanation given of them; for these motions must take place previous to the supposed changes in the state of the air, and cannot be caused by them.

Boerhaave endeavoured to account for the alternate action of the muscles of respiration, by the excess or defect of the nervous fluid, occasioned by the compression of the arteries which furnished the material for the secretion of this fluid in the brain, in a greater or less degree, by the greater or less expansion of the lungs. In this hypothesis so many gratuitous suppositions are implied, that it is hardly necessary to give it a particular examination. Respiration is, to a certain degree, dependant on volition. For a time we can hold the breath without difficulty, and, it is probable, that it is rather the intolerable uneasiness which is excited, that prevents the will from continuing the suspension of respiration for a longer time, or even till life ceases, than any want of physical power of the mind over the muscles concerned in this function. Moreover the influence of the will seems exerted to a certain degree, in continuing the motions of the muscles of respiration, even in the ordinary states of the system; for, in sleep, when volition is suspended, the respiration is slower, and the same happens when the attention is strongly engaged by any means.

In dyspnœa the agency of the will is more conspicuous, and muscles not ordinarily employed in dilating the thorax, are called into action by means of it. Possibly, as supposed by some philosophers, the first respiration in a child just born, may be occasioned by a peculiar sensation; or, as it may be expressed, an *appetite* for air, according to Dr. Darwin, or from the uneasiness occasioned by the accumulation of blood in the lungs, according to Haller, to the irritability of the lungs, or bronchial vessels, together with the consent between these and the intercostal muscles and diaphragm, the motions of inspiration and expiration seem principally to be ascribed. Co-operating with these, at least in general, is a certain degree of voluntary effort, excited by a peculiar uneasy sensation; still much is wanting to compleat a satisfactory explanation of this essential part of the animal œconomy.*

The utility of respiration, or at least the principal purpose which it answers, and which is so indispensable to the continuance of life, is far from being thoroughly investigated. Some change is induced in the blood by the action of the air, which appears to be the circumstance on which the necessity of this function depends. The nature of this change

* De Haen, Ratio Medendi, vol. ii. p. 108, relates a case, which seems to be at variance with all the theories of respiration which have prevailed. The whole of the viscera of the thorax were found connected together, by firm and close adhesions; and from the appearance of which it was concluded, that they had been formed long before death, consequently respiration was, in some measure, continued, notwithstanding obstacles, which, a priori, would have appeared incompatible with this function.

however, and the subsequent purpose answered by it in the other parts of the system, seem not so well understood as some modern theorists have endeavoured to make it appear. It was supposed that oxygen was absorbed from the air of the atmosphere, and diffused through the mass of blood, where it acted as a stimulus to the heart and arteries, or even to the whole system; the latest experiments, however, seem to have shewn, that the whole of the oxygen taken into the lungs in inspiration is consumed in forming the carbonic acid which is expelled in expiration; the stimulus which excites the heart and arteries seems to be the mechanical one of distention. That respiration was the cause of animal heat, had been endeavoured to be shewn previous to the theories just alluded to, and these were modified so as to afford an explanation of the dependance of the power of generating heat in the living body, on the function of respiration, according to the principles of the antiphlogistic system of chemistry. Notwithstanding the objections made to this hypothesis (some of which, it must be confessed, are difficultly evaded), it appears to be not without some plausibility, when it is considered, that the temperature of the animal body is universally higher in proportion, as the pulmonary system is more developed and more extensive. Thus the heat of birds is greater than that of the mammalia, and of these than fishes and amphibia, and the extent of the organs of respiration is in these several orders of animated beings in the same ratio. Some connexion between the two

functions is almost undeniable, and it appears more plausible to suppose, that animal heat is caused by respiration, than that this function should answer some collateral purpose connected with the production of heat in the body. Another consideration is, that the specific heat of arterial blood is greater than that of venous, and the arterialization is certainly known to be effected in the passage through the lungs. This fact is independent of any particular theory which may be adopted as to the chemical changes which the blood undergoes in respiration; whether these consist in the absorption of a particular principle from the air, the escape of certain matters from the circulating mass, which are become effete or superfluous, or some other process different from either of these. Still much uncertainty remains as to this theory; and animal heat, if it be really produced by respiration, does not seem to be the sole purpose answered by it, nor that the cessation of which renders suspended respiration so speedily fatal.

The most obvious difficulty, and that which is in some measure common to it, with all the theories which have ever been invented on this subject, is, that it does not explain the uniformity of temperature of the animal body, under the varieties of the surrounding medium. Respiration goes on with the same degree of velocity, whether the temperature of the atmosphere is greater or less. It has been said by the chemists, that the greater density of the atmosphere in colder climates, occasions a greater quantity of oxygen gas to be taken in by the lungs, and

consequently a greater quantity of the pabulum of heat. But then it is to be considered, that the oxygen gas, under these circumstances, is more condensed, has less specific caloric, and will give out less, on becoming fixed. A greater quantity may be inspired, but it will not keep up the temperature of the animal body proportionably. Again, the cutaneous transpiration has been stated to be the means by which the superfluous heat is occasionally carried off; but this is contrary to the facts, which shew that certain animals preserve their temperature in thermal waters, where transpiration is almost impossible.—"Anderson, Vallisnieri, Sonnerat ont observé des serpens et des grenouilles qui vivaient "sans augmentation marquée de chaleur dans les "eaux thermales, a travers lesquelles la perspira-"tion étoit presque nulle: dans la fievre sudatoire "(febris sudatoria), le corps du malade est couverte "de sueurs et cependant la temperature loin de "faiblir monte à un degré excessif et penible à "supporter."—*Dumas*, tom. iii. p. 554.

Besides this, it may be considered that the increased action of the vascular system must precede an increase of transpiration, and that thus an increase of temperature will be produced.

In animals which hybernate, as the hedge-hog, if the surrounding air, is even ten degrees below the freezing point, the animal heat has been observed to be forty-four. At the instant they are awakened from their torpidity, the animal temperature rises above one hundred. Their temperature is raised much sooner than could be effected by the heat

evolved in the first moment of respiration.—*Wilkinson on Galvanism*, vol. ii. p. 428.

In mal-conformation of the vital organs, when the action of the lungs was necessarily impeded, the temperature has been found of the natural standard.—"At Rotherhithe, a boy, ten years of "age, had the foramen ovale perfectly open. The "surface of his body had so deep a tinge "that he was usually known by the name of the "blue boy. There was an universal languor in "the circulation. He was soon fatigued. The "temperature of his body was ninety-eight."—*Ibidem.*

It is to be considered that chemical changes are incompatible with vitality, and therefore cannot be the source of any function connected with and dependant on the actions of the living body. The decomposition of the solids and fluids which does actually take place, is subsequent to their separation from the living system. Animal heat is evidently produced by, or, at least, dependant on the energies of vitality.*

In the experiments of Dr. Fordyce and others, in an heated room, the bodies of the persons subjected to the experiment, were covered, after some time continuance in the very elevated temperature, with a profusion of moisture. This most probably arose from precipitation of water from the air of the room, in consequence of the greater coldness of the bodies, and not from corticular transpiration; for the same took place on other substances,

* This objection is made to the theory which derives animal heat from respiration, by Dr. Bancroft, in his Essay on the Yellow Fever.

placed in the room, as a Florence flask. At any rate, the efforts of the excessive temperature were not alleviated by this means; on the contrary, they become much greater than they had been before.

The production of animal heat has as yet not been shewn to depend on any of the known causes of heat in the other parts of nature, and the manner in which it does appear to be generated, the laws by which it is regulated, seem to point to a source totally distinct from any thing in inanimate matter, and to be peculiar to the vital principle. The calidum innatum of Hippocrates, and the ancient physicians and philosophers, may perhaps be considered as a modest and philosophical mode of expressing this truth. Some modern writers have advanced opinions nearly similar, as Dr. Fordyce, whose very curious and interesting experiments have been so often referred to; and, probably Dr. Cullen, although this celebrated professor seems, at some part of his life, to have imagined a motion of the nervous fluid the source of animal temperature. Some of his pupils at least have broached a similar doctrine, apparently derived from his prælections.* The connection of the heat of the body with the life is an obvious truth, which seems to have occurred to very early enquirers into the laws of the animal body. Dr. Currie thus considers the power of supporting a certain temperature as the most essential part of the vital energy, although he adopts the theory of animal heat depending on respiration.

* See a Thesis de Calore Animalium, by Dr. Gustavus Brown of Maryland.

Increase of energy in the system, particularly in the heart and arteries, is almost uniformly attended with increase of temperature. It ought, however, to be observed, that the increased action of the sanguiferous vessels, is not to be estimated solely by the frequency of pulsations, which would lead to a very opposite conclusion. It is the velocity or frequency of the contractions, multiplied into the force with which they take place, that constitutes the *quantity* of arterial action, if we may so speak, as in topical inflammation in all its varieties. Other circumstances, as the state of the stomach, and the function of digestion, to which animal heat has been attributed by some as its sole source:—we have no reason for concluding, that any evolutions of heat takes place in consequence of chemical changes in this organ. But there seem to be some grounds for the opinion, that the stomach, which is so well known to be intimately connected with the state of the rest of the system, has some influence in regulating the production of animal heat. The secretions, or other changes, which occur at the termination of the blood vessels, have been by some regarded as the source of heat; but these processes are too gradual to admit of the supposition in question: besides, there is no known connection between them and the degree in which the body is heated.

The nerves are, in all probability, in some measure connected with this function, as with all others; but there is no part that they are so in any other mode. The electric matter in the nerves

producing heat, is one of those gratuitous hypotheses which it may suffice to mention cursorily.

Perhaps more accurate observations, or more multiplied, would tend, in a great degree, to elicit some conclusion as to, or at least to generalize, what is known on this subject. De Haen's experiments, apparently very accurate, and those of the late Dr. Currie, are almost the only observations which are extant.—*De Haen R. M.* vol. i. p. 117.—*Currie's Med. Reports.*

The sensations of heat and cold do not always correspond to the real state of the temperature of the body, so that a diminution of temperature shall be constantly with a sensation of cold, and the reverse. In the cold stage of fever it has been asserted, the temperature of the body is not less than in health, although the patient's complaints are of cold; and from this supposed depraved sensation, a diminished energy or alteration of some kind in the sensorium commune, has been inferred. De Haen relates some singular instances which go to establish this fact; one in particular (R. M. vol. 1, p. 121).—" In hemitritæa quam cum continua febre, " intermittens quotidiana formabat, homo intermit- " tentis paroxysmum tanto cum frigore experiebatur, " ut si frigus modo abesset, morbum totum flocci fa- " cere se diceret, propter immane vero frigus se sus- " tinendo ultra non esse. Easdemque querelas mul- " tis in paroxysmis repetivit. Dabat tamen thermo- " metrum passim 104 gradus. Neque vel hilum " ascendit illud, dum in ardente princeps calori ad- " moveretur. Et dum per sequentes paroxysmos

"frigus imminueretur, gradus tamen caloris 100, "99, 98 fuere. Frigoris porro, perceptio homini "vivida, frigoris signa, algor, tremor, stridor den- "tium evidentia erant: dum interim calorem natu- "rali superiorem notaret thermometrum, dumque "nos repetito sæpe examine hominem tepentem ac "fere naturaliter calentem, passim deprehendere- "mus. Expectabilis quid ex pulsu observatum "sit? Is more solito, tempore frigoris febrilis, "celer parvus, contractus utrumque. Caloris vero "tempore plenior, liberior, major. Thermome- "trum semper sub axillis adplicatum ita adscendit, "cum tamen portissimum frigoris sensum æger toto "thorace perciperet."

It may still admit of doubt, how far such cases as the preceding are to be considered as exemplifications of the general rule, or, as is more probable, are to be ascribed to some singular anomaly. The late Dr. Currie states (Medical Reports), that the sensations of heat and cold, in pyrexia, agree with the real temperature of the body, although this may not be the case in diseases of another class; viz. the neuroses, the essence of which consists in an alteration in the state of those organs which are the instruments of sensation. Error may possibly arise from not attending to the part where the thermometer is applied. If the instrument, placed under the tongue, or in the axilla, indicates a natural temperature, or a greater than this, while the patient complains of cold, the extremities not being examined, the existence of a depraved state of sensation cannot with certainty

be inferred. This source of fallacy may particularly occur at the coming on of the cold stage, or at its termination of this in the hot fit, both of which processes are gradual when the temperature of different parts may be supposed to be very different; in the mean time, the complaints made by the patient of cold or heat, will be determined by that which predominates on the whole.

SECRETION.

THE mass of blood distributed over the whole system, besides other purposes, furnishes materials from which the waste of the solid parts is restored, and from which, certain fluids, differing both from each other, and from the blood itself, are formed, or, as it is said, secreted.

The apparatus, by which this function is performed, consists of certain organs, called glands, or merely of small vessels, with open mouths—exhalants.

Many divisions have been made of the secreted fluids. First, according to their composition, they have been divided into different classes,—aqueous, glutinous, mucous, oleaginous; otherwise, from the purposes they answer, some being made use of for some specific purpose in the animal œconomy, and others being excrementitious. In another point of view, they have been distinguished as to the manner of their formation. Some existing in the mass of blood, and requiring only mechanical separation, or filtration; and others being different from any of the constituent parts of the circulating mass,

and consequently being formed by a more elaborate process. This last is the case with those fluids which are secreted by a complicated glandular apparatus. But whatever utility there may be in these divisions, it is extremely difficult to draw any positive line of demarcation between any of the different classes in the divisions just alluded to. For, with respect to the first division, there are fluids which partake of the nature of more than one of the classes pointed out, containing, at the same time, mucilaginous and oleaginous parts—as the bile. The urine contains substances which do not fall under any of the general heads laid down.

The second division is also objectionable, because, with respect to some of the secreted fluids, it is not well ascertained whether they are subservient to any peculiar use, or are merely excrementitious; and there are two secreted fluids, which although not made use of in the system in which they are formed, can hardly be said to be excrementitious,—these are the milk and seminal fluid.

There are hardly any secreted fluids which can be formed solely by mechanical separation, not even the watery fluid poured out by the exhalants, opening in cavities.

No satisfactory explanation has as yet been given of the manner in which this function is performed; but the hypotheses that have been formed on this subject are very numerous.

The first to be considered is that of the chemists,* who imagined, that in every gland there was a pe-

* Van Helmont, Willis, Belliné.

culiar ferment relative to the nature of the fluid to be secreted, by means of which the change of the blood into bile, urine, &c. was effected in a manner analogous to the changes of composition produced in fluids out of the living body by ferments, the ferment assimilating a portion of the circulating mass. The objections to this are, that it rests on no foundation, except mere speculation.

It is not attempted to be shewn, how the ferments are produced. It is hardly possible to suppose, that in every gland there exists, from the first formation, a sufficient quantity of the ferment to answer the purposes of secretion during life; there must, therefore, be some mode by which a supply or renovation can be produced. How is this to be effected? Is it by means of other ferments? then a progression of successive ferments, ad infinitum, would result. If the gland has a power of forming the ferment immediately, why may it not as well be supposed to form the fluid which it secretes, in a similar manner without the intermedium of the ferment? Very much a-kin to the doctrine of ferments is that of germs or analogous molecules.* These germs were supposed to exist in every gland; thus the liver contained the germ of the bile, &c. which attracted similar particles from the blood, so as to form the respective fluids. But if these germs existed from the first formation (besides the difficulty of conceiving this), the secreted fluids would always retain the same character; whereas, besides changes from ac-

* Leibnitz, Helvetius, &c.

cidental circumstances, there are differences in the composition of the secretions at different periods of life. If the germs are formed occasionally, the supposition of their existence becomes superfluous; because it is as easy to imagine, that the secretions are formed immediately, without any such intervention, whatever may be the power concerned in their production.

Many modern writers, without adopting the above-mentioned hypothesis of ferments, have supposed that secretion was a process analogous to fermentation; but, as far as can be observed, there is no reason to imagine that the phœnomena of secretion are similar to those which take place in fermentation. Fermentation is always attended with more or less extrication of vapour; the access of atmospheric air is an essential circumstance. Fermentation is a process which takes place slowly; secretion often very rapidly; always in too short a time to admit of the gradual changes of fermentation. Putrefaction has been supposed to be concerned in secretion by some physiologists; but in none of the fluids of the healthy body are there any signs of putrefaction (except perhaps the urine), and in putrefaction after death, nothing like any of the secretions has ever been observed.

The second class of hypotheses are those founded on mechanical principles.* The blood was supposed to contain molecules of different forms; and the secretory ducts, or certain pores in these, in each gland, were also of a peculiar form. These

* Descartes, Borelli, and others.

pores consequently admitted only certain molecules, whose figure corresponded with their own. Every gland was, therefore, a sieve, whose apertures were of a different figure from those of every other. This hypothesis is founded on no analogy, for mere mechanical separation never produces any change of composition.

Secretion, according to this theory, must always take place with extreme slowness; for the particles must be presented one by one to the pores or extremities of the duct, yet many of the fluids are secreted with great rapidity on some occasions. There must be some power also by which the particle is always presented in a particular direction, otherwise, the correspondence between the shape of the particle and the pore, would no longer hold, supposing they were irregular in their figure. If these circumstances were left to the casual agency of the motion of the blood in the vessels of the gland, secretion would often not take place at all, or would go on irregularly. Pores of a peculiar figure would not only admit particles of the same figure, but those whose figure was different, provided their size was less in a certain degree. Hence the fluids would hardly ever be formed in a pure state. The bile, in jaundice, after being absorbed and carried into the mass of blood, is separated by the kidneys, and almost every gland of the body. This circumstance is incompatible with the theory in question. The vessels of glands are liable to relaxation or constriction; in these cases the secretions are in fact changed to a certain degree; but, according to the mechanical theory, a slight variation in the

state of the secretory ducts, or their open mouths, might produce a total change in the secreted fluid; one gland might form the fluid usually secreted by another. The secretions are effected by causes which can have no effect in changing the size or figure of the pores,—as passions of the mind.

The vessels are composed of flexible materials; hence, if any force was applied, the shape of their extremities might be so changed, as to admit particles of a different shape from those to which they are naturally adapted, and the secretions be in consequence altered.

Keill, Hamberger, and Sauvages, have referred secretion to some modification of the attractive forces of matter, or to some relation between the weight of the secreting organs, and that of the fluids; but this is inconsistent with any known laws of attraction, and entirely hypothetical. Stahl, and his school, considered secretion, like all the other functions of the system, as the effect of the immediate agency of the rational soul; although they combined, with this supposition, some of the theories just mentioned. The influence of different states of the mind on several of the secretions is undoubted. Anger increases the flow of bile, and seems to diminish that of the saliva and mucus of the mouth. The lachrymal gland is also acted on by certain passions. The urine is increased by terror. The secretion of semen seems always to be occasioned by a particular appetite. The secretions of gastric fluid is also apparently under the influence of causes of this kind.

A peculiar action of the vessels of the glands is a

favourite idea of many, particularly of the Hunterian school; but all that can be conceived to result from this, is merely mechanical, and no change of composition. Dr. Darwin supposes certain appetencies in the vessels of glands, by means of which they select particular parts of the fluids. Very similar to this is the theory of a late systematic writer on physiology.—"La sensibilité specifique des organes les met en rapport avec les matieres dont se compose l'humeur de chaque secretion. Elle preside au choix de ces matieres que les vaisseaux leur apportent, et quils élaborent et preparent chacun à sa manière. C'est par l'effet de cette sensibilitè vitale, de ce fact sensitif, que les organes secretoires distinguent, attirent, absorbent, retiennent, et frappent, d'une caractère specifique les fluides qui leur sont naturellement destinês, et qui deviennent identiques avec telle ou telle humeur par l'effet d'une veritable assimilation."—*Dumas Princip. de Physiol.* tom. iv. p. 520.

But these are suppositions, which it is hardly possible to conceive with sufficient distinctness, to call them explanations. On the whole, it seems impossible not to assent to the observation of Haller, when treating of secretion—"Multa in physiologia obscura, hac functione obscurius nihil."

But although the principal or most essential part of this function is hid in impenetrable obscurity, there are many of the circumstances relating to it, or preparatory to it, which have been investigated successfully. A peculiar distribution of blood vessels takes place in most glandular organs, and pro-

bably contributes to the specific differences of the respective fluids. Nervous influence is essential to secretion. This is proved, not only from the facts just stated of the influence of states of the mind, but experiments in which the nerves were divided. Thus Haller found that the division of the nerves of the eighth pair, put a stop to the secretion of the gastric fluid. Absorption, after separation of the fluid from the blood has taken place, often modifies and changes its nature. The different structure of the glands themselves is also to be considered. The irritability of the secretory and excretory ducts of glands is very great, as is shewn by their being acted on by very minute quantities of certain substances. It is not certain whether any difference in the blood sent to particular glands, modifies the secretion in any manner; in one instance, however, that of the liver, this does appear to be the case, venous instead of arterial blood being the source from whence the biliary secretion takes place.*

* A late writer has endeavoured to refute the generally received opinion, that the bile is secreted from the blood brought to the liver by the vena portarum; and to prove that the hepatic artery (analogous to other cases of secretion), is really concerned in this process; an instance is cited from the Philosophical Transactions, where the vena portæ was entirely wanting, yet good and perfect bile was found in the gall bladder. But little can be inferred from cases of original malconformation, as to the ordinary functions of the animal œconomy; for wherever any organ is wanting, there is generally some compensation by another part performing its office. The heart has thus been deficient in the original conformation, and the circulation must have been carried on by the muscular power of the arteries alone. The experiment of Malphigi of tying the hepatic artery, seems decisive in proving that this artery is not the source of the biliary secretion, bile was still secreted; for although the vessels were not exhausted of the blood previously contained in them, yet this quantity

The formation of pus has been by many considered as a secretion. Dr. Simpson, of St Andrew's, seems to have been the first author of this opinion. He states an abscess to be "nova quasi glandula." Mr. J. Hunter was a most strenuous advocate for the same hypothesis. This is perhaps explaining ignotum per ignotius, although it must be admitted that some analogies exist between the two cases as far as observation reaches.

must have been very inconsiderable; besides the ligature on the artery must have prevented it from performing its functions.—*Powell on the Bile*, p. 28 et seq.

See Note H.

DIGESTION.

THE whole alimentary canal may be considered as one great glandular apparatus, whose office it is to separate the chyle from the mass of food. The substances taken into the stomach having been first communicated by mastication, are acted on by various agents,—heat, water, perhaps certain aeriform fluids. Some degree of fermentation seems to take place, or, at least, some separation of parts, which may be considered as an approach to that state. The principal agent, however, in effecting the change of the alimentary matters into chyme and chyle, is the gastric fluid. The manner in which this fluid occasions such effects, is by no means well ascertained. Solution is the most prevailing theory; but something more than this is evidently necessary. A change of composition, or a decomposition, and subsequent recombination of parts, after a new manner, seems to take place. Perhaps the gastric fluid may be considered as a ferment.

The cause of that peculiar sensation which leads to the taking food into the stomach has been much disputed. To all the explanations on mechanical and chemical principles, the influence of the different states of mind and of habit are insuperable objections. It is probably to be referred to the want of accus-

tomed impressions on the nerves, similar to the pain of cold. The want of a proper degree of distention of the muscular fibres of the stomach may also contribute to this uneasy sensation. Dr. Darwin mentions an instance of a woman, who having once eaten a very large quantity of food for a wager, was never afterwards satisfied with an ordinary quantity. When food has been long withheld, the sensation is not confined to the stomach, but is a feeling of languor over the whole system. This, however, seems owing rather to the connexion or sympathy between the state of the stomach and the other organs, than to the want of supply of aliment.

During the first period of digestion, the whole forces of the system seem concentrated on the organs concerned in this process; all the other functions are performed with diminished energy; the motion of the muscles becomes weak and languid; the exercise of the intellectual powers difficult; the secretions suppressed; the temperature of the body diminished, or, at least, a sensation of coldness takes place, although afterwards the heat is increased. This arrangement cannot be disturbed with impunity. Exertion, either mental or bodily, soon after taking a quantity of food into the stomach, is attended with great inconvenience. On the other hand, whilst any important process of any other kind is taking place, the digestion of food is apt to create great disturbance in the system. Thus the crisis of an acute disease, the suppuration of wounds. Convalescence from disease may be impeded by this means.*

* See some important remarks on this subject in Dumas Princip. de Physiolog. tom. iv. p. 357.

The effect of mental exertion, in diminishing the actions of these organs is well known.—" Vim " vero animæ in ventriculum quotidianæ demon- " strant observationes, et hanc quisque in semet ipso " experiri potest, quo quis enim cogitat intensius, " reflexumque mentis actum vehementius exercet, " eo, cæteris paribus, cibos ingestos coquit diffici- " lius tardiusque; et contra quo quis animum a " reflexione liberum magis habet, eo felicius citius- " que."—*Tissot de Valetudine Literat.* p. 13, 14.* —*Ramazzini de Morb. Artif.* p. 340.

The influence of the state of the digestive organs on the functions of the brain, and vice versa, is one of the most trite observations in physiology and pathology. Læsions of the sensorium commune in general induces nausea, vomiting, and indigestion. But there are facts apparently of an opposite nature. In apoplexy and hydrocephalus internus, appetite and digestion are sometimes more vigorous than in health. Diminution or decay of the mental faculties has been often followed by corpulence, when the person was previously emaciated. These circumstances have, by some physiologists, been adduced as proofs that the functions of simple life are independent of nervous influence, and that their energy is even diminished by it. It may, however, be supposed, that this increased energy of the digestive organs is a morbid state as much as the diminished action in other cases, and connected also with certain diseased states of the brain.

* This circumstance was remarked by the ancients. Vide Aretæum lib. iv. cap. vi. Morb. Diuturn. Celsum, lib. i. cap. 2.

On the other hand, a totally different view of the subject may perhaps be taken. Possibly these phœnomena may be proofs of the dependance of all the functions of the system on one common principle. A priori, if it is taken for granted that the same cause gives rise to the animal and natural functions, the most obvious supposition would be, that as this power acted with more energy in one direction, or in supporting one set of functions, it would act more feebly with respect to the others.

The connexion of the organs of digestion with the thoracic viscera is also conspicuous. Difficulty of breathing is brought on by substances taken into the stomach independent of the mechanical impediments from the distention of this viscus. The actions of the heart and arteries are also influenced by states of the stomach and intestines. Syncope may be induced by this cause.—*Zoonomia.*

The hypothesis in question is, however, by no means a recent one. The nerves have been imagined to be the vehicles of the *succus nutritius* by many of the older anatomists.*

* Willis de Cerebro et de Anima Brutorum.

NUTRITION.

NUTRITION is that function by which the solid parts of the system are repaired. Every part of the body is continually wasting. The tendency to putrefaction, inherent in the matter of which it is composed, is counteracted to a certain degree by the vital powers, but not entirely destroyed. Certain decompositions are hence taking place, and the necessity of fresh supplies is the consequence. That the arteries are the channels by which the matters to be assimilated to the different organs are conveyed to them, there appears to be little or no reason to doubt. The arguments in favour of the nerves performing this office, seem entitled to no consideration.* The nerves only influence nutrition so far as

* The experimentum crucis with respect to the hypothesis of the nerves conveying nutritious matter is the following:—"It "is well known that if powder of madder root is mixed with "the food of a young animal, the bones become red; or if a "bone has been broken, that the callus joining its parts will be red. "The serum of the blood, in the first place, is deeply tinged; but "the red colour of the bones is not solely, or even chiefly owing to "the coloured serum, or blood circulating; for I have found, that after "injecting water into the vessels, till those were emptied of the "blood, and the water came out colourless, the tinge of the bones "appeared equally red, and was therefore plainly owing to a great

they are necessary to all the functions dependent on life. A paralytic limb is often emaciated; but this is probably from the arteries having lost their power, or perhaps from want of motion or exercise, which is in general necessary to the vigour of any part of the body. Here, however, insuperable difficulties present themselves. By what means does the blood, or any of its constituent parts, become assimilated to muscle, bone, nerve, &c. The power effecting this was designated by the ancients under the terms of *digestive, alterative,* and *retentive.* Van Helmont gave to it the whimsical name of *blas alterativum.* Lord Bacon called it—"*Motus assi-* "*milationis,* sive *multiplicationis,* sui, sive etiam "*generationis simplicis.* Nempe per hunc motum "corpora similaria vertunt corpora alia affinia, aut "saltem bene disposita et præparata in substan- "tiamet naturam suampartes solidæ plantarum "et animalium, veluti folium, flos, caro, os et sie "de cæteris, quæ singulæ ex succis alimentorum "assimilant et generant substantiam successivam et "epicisiam. Neque enim cum Paracelso delirare "juvat, qui (distillationibus suis scilicet occæatus), "nutritionem per separationem tantum fieri voluit, "quodque in pane vel cibo lateat oculus, nasus, "cerebrum, jecur: in succo terræ radix, folium, flos. "Etenim sicut faber ex rudi massa lapidis vel ligni "per separationem et rejectionem superflui educit "folium, florem, oculum, nasum, pedem et similia:

"quantity of the red earth added to the bones in the time of their "growth. But this earth was not transmitted by the nerves, for the "colour of these, as I found, remained unchanged."—*Monro on the Nervous System.*

" ita Archæum istum fabrum internum ex alimento " per separationem et rejectionem educere singula " membra et partes, asserit ille. Verum missis nugis, " certissimum est partes singulas tam similares quam " organicas, in vegetabilibus et animalibus, succos " alimentorum suorum fere communes aut non mul- " tum diversos, primo attrahere cum nonnullo de- " lectu, dein assimilare et vertere in naturam. Ne- " que assimilatio ista aut generatio simplex fit solum " in corporibus animatis, verum et inanimata ex hac " re participant: veluti de flamma et aere dictum " est."—*Nov. Organ.* p. 248, 9. In the " His- " toria vitæ et mortis," p. 339, other expressions are made use of. " Concurrere etiam debent ac- " tiones partium exteriorum: ut sicut *facultas in-* " *terior* alimentum emittit et extrudit, ita *facultas* " partium exteriorum idem arripiat et attrahat " quoque imbecillior fuerit *facultas concoctionis*, eo " magis opus est auxilio concurrente *facultatis at-* " *tractivæ*."

The interior mould of Buffon, and the *nisus formativus* of Blumenbach, are only different expressions for a fact, without any reference to the cause. The organic molecules of Buffon are only animals in miniature. Dr. Darwin observes, that these particles being themselves compounded, must themselves require nutritive particles to continue their own existence, and must be likewise liable to undergo a change by our digestive or secretory organs; otherwise mankind would soon resemble the animals which they feed upon. Dr. Darwin's own theory is, that in consequence of certain appetencies the nutritious particles are selected by the several parts;

in the same manner he supposes, that the glands select from the mass the materials agreeable to their taste. Thus nutrition and secretion are performed in a similar manner, except that in the latter the particles selected from the mass of blood are parted with again, and in the former are retained. This can hardly be conceived distinctly, without supposing specific sensations in every gland and every vessel of the body; and the power by which the several parts are enabled to seize on their appropriate matters is still to be explained. This author has also revived the old opinion, long exploded, that the whole animal system may be considered as consisting of the extremities of nerves, or of having been produced from them, and hence endeavours to shew, that all the solid parts of the body having originally consisted of extremities of nerves, must require an apposition of nutritive particles, of a similar kind. But if this was the case, it may be asked, what need would there be of any *selection* of particles?

In considering this subject, the greatest difficulty is to conceive how the vital properties, sensibility, irritability, &c. are communicated to the substances which serve to repair or augment the organs of the animal body. The substances used for food, in their constituent principles, agree with the animal body to which they are assimilated. In order to this, decomposition must first be produced, and other combinations ensue of a different kind. A process of this kind takes place in the stomach for the formation of chyle: perhaps again in the conversion of this fluid into blood; and, lastly, in the application

of certain parts of the circulating mass to form the different solid parts. But it is utterly inexplicable how any combinations should impart the properties of contracting on the application of a stimulus, of spontaneous motion, or of sensation.*

Many authors have explained the function of nutrition after the following manner:—They imagine that the solid parts, as bones, muscles, &c. are continually wasting away† by the friction which they undergo in the different actions of the system, and that thus small cavities are left in them. These cavities are filled up by means of the glutinous part of the blood, which is attracted by the organ as it flows by it, the thinner parts of this fluid passing by. This process is forwarded by the motion and compression which the parts are perpetually undergoing, and it takes place in a gradual manner if the cavity is not entirely obliterated at first; the smaller depression which remains, attracts and detains a further portion of gluten, until the superficies is level. If there is any protuberance produced, this is worn away by the stream of blood by which it is perpetually washed. The nutrition of the blood-vessels themselves is easily understood on this principle, and that of the other parts is performed by means of the small vessels which ramify through them, or open into cavities. The insufficiency of this theory is apparent, from its not explaining how from the general circulating mass each organ acquires parts whose composition is similar to its own, and also its peculiar organization. The removal of superfluous

* See Note I.

† Arbuthnot on Aliments.

parts seems evidently to be the province of the absorbent vessels, and not to be caused by mechanical means; for friction seems rather to forward the growth of parts.

Although the arteries are evidently concerned in nutrition, conveying the nutritious fluid to every part of the system, and that probably some kind of action of their smaller branches takes place in the application of it; it seems to be a fact, that an increased energy of this system (at least if above a certain degree), impedes the function of nutrition. Hence, probably, the emaciation in febrile diseases, in part (although this is to be ascribed, in a great measure, to the want of supply of aliment), those of the sanguine temperament are thus generally of a more spare habit than the phlegmatic. It may indeed be objected to this, that inflammation produces new parts, or an increase of bulk.

The deposition of fat, in the cellular membrane, when it exceeds a certain quantity, is to be considered as a morbid process, as much as the deposition of water in anasarca; it does not appear that it answers any specific purposes in the animal œconomy. It is not a reservoir of nutritious matter; there is no proof that it is ever absorbed again, so as to be applied to the purposes of nourishment.

Growth is most probably effected in the same way that nutrition is, whatever that may be. Elongation of the parts seems to be produced by the distention of the blood-vessels from the impulse of their contents, whilst they are not become too rigid to resist this.

The reason why an animal body is not immortal, or what occasions decay, and death, after a certain period, does not seem to admit of any explanation.* Rigidity of the simple solid, and inirritability and insensibility of the living solid, are indeed ascertained to take place, but the causes of these changes are yet unknown.

* Stahl Theoria Medica vera, in Capite cui titulus. Quod ratio reddi non potest cur homo naturaliter moriatur.

GENERATION.

THE period of puberty is marked in both sexes by many changes in the state of the system in general, as well as of the genital organs. In the male, the growth of the beard, the alteration in the voice, often an increase of growth, the disappearance of certain diseases arising from debility. Most of these circumstances have, in general, been attributed to the absorption of semen. The growth of the beard, and the greater tone of the voice, seem to arise from some consent between the throat and the organs of generation. The swelling of the testes in the cynanche parotidæa shews also the same circumstance.

The changes which are produced in females at the same period, are not so considerable as in the other sex. The voice is not altered, nor is the vigour of the whole system increased in so great a degree; yet this is the case in some measure. A peculiar state of the ovaria has been supposed to take place at this period, which has a great share in exciting the action of the uterine vessels, and producing the menstrual flux, disposing to the exer-

cise of venery; and that this state of the ovaria, analogous to what happens in the male sex, is necessary to give tone and tension to the whole system.* This is confirmed by a case which occurred to Mr. Astley Cooper, in which the ovaria were wanting. In this instance the venereal appetite was entirely wanting, and the growth of the body imperfect. The earliest theory of menstruation was that of ferments. The lunar influence was also imagined by many to be the cause of this periodical discharge. Plethora has been a prevalent theory both in ancient and modern times.† Local plethora has with more probability been assigned by others as the cause; and this, combined with the influence of habit, may perhaps serve to explain the recurrence of the menstrua at regular periods.

The manner in which conception takes place, and the embryo is formed, perhaps never can be developed. It is at least certain, that this has not been done as yet. What has been supposed to be animalculæ in the semen, exists apparently also in other fluids of the animal body, and they are not found in the seminal fluid of all animals.—*Haller, Prim. Lin.* sect. 882. The organic particles of Buffon are supposed to exist in the spermatic fluids of both sexes, and to be derived thither from every part of the body, and must therefore resemble the parts from whence they are derived. These organic particles, he supposes, become mixed in the womb, and produce a fœtus similar to both parents. An hypo-

* Cullen's First Lines, sect. 1001.

† Friend Emmenolog.—passim.

thesis very much resembling this is mentioned by Lucretius.* Dr. Darwin has observed, that according to this theory, there is no reason why the mother should not produce a female embryo without the assistance of the male. The primordium, or rudiment of the embryo, secreted from the blood of the parent, according to the author of Zoonomia, consists of a simple living filament; this filament is endued with a capability of being excited into action by certain kinds of stimulus. It may bend into a ring, and thus form the beginning of a tube. This living ring may now absorb a nutritive particle of the fluid in which it swims, and thus increase its length or crassitude, and, by degrees, the ring may become a tube. With this new organization new kinds of irritability may commence, and sensibility be acquired. New parts are afterwards formed in the same manner; and, with every addition of parts, new kinds of sensibility or irritability are acquired. These suppositions he endeavours to illustrate and confirm, by analogies particularly drawn from the phœnomena of vegetation; but the whole of his hypothesis is gratuitous.

Dr. Darwin says, sect. xxxix 9, 2.—"Another "thing difficult to conceive from those theories which "supposed the first rudiments to consist of a single "entity, was to answer the question, whether the "brain, or heart and arteries were first formed: as "the motions of the arterial system previously existed "seems to have been necessary for the secretion of

* Lib. iv.

" the sensorial power in the brain, and conversely " these motions of the arterial system seem previously " to require the sensorial power derived from the " brain. This difficulty vanishes when we believe, " that many parts of the young embryo can be begun " at the same time, as various formative fibrils coa- " lesce as they come into contact with each other, and " thus the rudiments of the brain and heart may be " fabricated at the same instant of time." But, again, we may ask, from whence is the sensorial power derived that is the cause of those motions of the fibre, which is the primordium of entity, and afterwards becomes the embryo?

According to Dr. Darwin, sensorial power, the cause of all the motions of the animal body, is secreted in the brain. This sensorial power, therefore, cannot exist in the fibre which is supposed to be the origin of the animal to be formed; and, consequently, none of the actions attributed to the fibre can take place in it. Irritation, sensation, &c. so far from being the causes of the formation of the animal, are themselves the result of an organization complete in all its parts, according to the Zoonomia. If the properties in question can belong to the fibre, independent of sensorial power, it would follow that the same might be the case with the parts of the animal when fully formed, and consequently the supposition of the existence of the sensorial power becomes useless. To imagine that the same powers or properties may arise from different causes, is directly contrary to all analogy. We may here remark, that it is singular that such

a philosopher as Dr. Darwin, should have given credit to the exploded absurdity of the effects of the imagination on the fœtus.

A single instance of a fœtus without a mouth, is sufficient to overthrow the hypothesis of the liquor amonii being the source of nutriment. Besides this consideration, this fluid is almost entirely water, a very small proportion of mucilaginous matter being mixed with it. The meconium, or fæces, found in the intestines of the fœtus, are probably derived from the secretions into the primæ viæ, principally bile.

Dr. Haighton, in Phil. Trans. 1797, has related a great number of experiments, which tend to establish many facts relating to this function. The male semen does not permeate the fallopian tubes, but probably acts only as a stimulus to the uterus; the ovaria swell and discharge the ovum, or what has been so called, into the uterus. These observations tend to prove, that the primordia of the fœtus are derived from the female.

Dr. H. concludes by referring Nature's steps through the different stages of this process to that law in the constitution, which is called sympathy, or consent of parts. The semen first stimulates the vagina, os uteri, cavity of the uterus, or all of them. By sympathy the ovaria vesicles enlarge, project, and meet. By sympathy, the tubes incline to the ovaria, and having embraced them, convey the rudiments of the fœtus into the uterus. By sympathy the uterus makes the temporary preparation for perfecting the growth and formation of the fœtus; and by sympathy, the breasts furnish milk, and finally,

neither semen, in a palpable form, nor as aura seminalis, is ever applied to the ovaria.

That the application of semen to the ovaria is not the cause of the evolution of the ovaria in the vesicles, is proved by the vesicles which the ovaria contain, undergoing the same changes after the sexual act, even when the obliteration of the fallopian tube of that side rendered the application of semen to the ovaria utterly impossible. Dr. H. made an incision in the flank of a virgin rabbit where the fallopian tube was situated. A portion of the tube was drawn out, and about one-eighth of an inch cut off; the ends were returned into their former position, and the wound closed and healed. On admitting the male to her, she shewed no reluctance, and became impregnated. Ten days after she was killed and opened; the tube was so obliterated as neither to allow air nor quicksilver to pass. Both ovaria retained their position and plumpness; the vesicles in both ovaries had burst, and their contents were discharged. In another experiment, both the ovaria retained their primitive plumpness, there were even corpora lutea in both. Those seated in the ovary of the obliterated side did not differ in any respect from the same bodies in the perfect sides; but they were unattended with fœtuses, whereas, on the perfect side, there were as many fœtuses as corpora lutea. Although the act of coition produces this evident alteration in the vesicles, alterative alike in both ovaria, in the mutilated sides as well as the perfect; there were fœtuses only in the perfect side; in the mutilated side there were corpora lutea, but no vestiges of a fœtus.

These researches shew great ingenuity; and, perhaps, may be said to carry the investigation as far as it has yet been pursued. The following remarks of Haller, in concluding the subject, may be added:—

"Fortuitum concursum atomorum, cæcas attractiones partium nutritiarum facile rejicias, improvidam futurorum finium vim fermentorum, animam structricem pulcherrimo operi adeo certo imparem, modulos interiores quorum nunquam ullam sanam ideam morte potui concipere, ad hypotheses referimus quas desiderium excudit explicandorum quæ inviti ignoramus. Mihi quidem experimentorum fides cum iis consentire videtur quæ mens ipsa ex suis causis secutura prævideat. Nempe hinc quidem pulcherrimam animalium fabricam ita variam ut ad propios et distinctos cujuscunque generis mores et officia, vitæque genus utique sit aptissima, ad leges omni humana geometria perfectiores acommodatam prævisos ad fines in oculo, in aure, in manu, utique demum manifestissime accommodatam, nulli infra sapientissimum creatorem causæ tribui posse mihi quidem certum videtur."—*Prim. Lin.* p. 471.

ERRATA.

Page	Line	
2,	11,	for reductions, read deductions.
	17,	omit the, before phœnomena.
4,	9,	for greatest, read a greater.
	13,	after course place a colon; and omit the stop in the next line.
10,	23,	for fibrilla, read fibrillæ.
27,	9,	omit the parenthesis.
29,	12,	omit the semicolon.
31,		for motua, read mutua.
33,	23,	omit of.
36,	14,	for same, read name.
37,	6,	from the bottom, for anima, read animæ; in the next line, for qui, read quæ.
38,	6,	from the bottom, for materia, read materiæ.
	7,	————————, for quondam, read quandam; and for anima, read animæ.
39,	8,	omit the words "if it exists in the body," and the next line.
41,	2,	for mitto, read multo.
42,	3,	for lavis, read lævis.
44,	8,	from the bottom, for phœnomena, read phœnomenon.
49,	19,	for papilla, read papillæ.
49,	6,	——— ———, for sensation, read sensations.
50,	3,	after organs make a full stop; in the next line omit the semicolon.
56,	5,	for causes, read lenses.
	9,	for senses, read lenses.
59,	9,	for hoc, read hæ.
61,	3,	omit the asterisk.
	15,	for presented, read preserved; and for their, read this.
	4,	from the bottom, for idras, read ideas.
		Note, for regime, read regione.
65,	7,	instead of for, read or.
	8,	for these, read those.
	12,	for sense, read senses.
69,	9,	omit of.
	14,	for composed, read comprised.
71,	4,	from the bottom, after when the nerve is inserted, read are not perceived, and omit are insensible to light, &c.
72,	13,	for truly, read merely.
73,	10,	for eye is, read eyes are.
74,	12,	for objects, read images.
	22,	for determined, read ascertained.
	2,	from the bottom, for seems, read seem.
75,	16,	for numbers, read number.
113,	4,	for pertinus, read penitus.
120,		for become, read became.
121,	15,	for evolutions, read evolution.
	2,	from the bottom, for part, read proof.
123,	8,	for expectabilis, read expectabitis.

NOTES.

A.

THE activity of the organs of sensation does not appear to have been an hypothesis which originated with this writer.—*Vide Stahl Theoria Medica Vera Cap. de Sensu—Dumas Princip. de Physiolog.* tom. ii. p. 151,—" L'activité étant un charactere essentiel du sentiment, celui-ci n'existe qu'en vertu d'une certaine action des organes, et il se proportionner au degré d'attention dirigée vers les causes externes, ou internes qui le provoquent."

In the preceding parts of the same chapter, some curious remarks on this subject are to be met with. The ancient Stoical philosophers seem to have maintained a similar opinion.

Αισθησις λεγεται κατα τους ζωικους, το, τε αφ ηγεμονικου πνευμα, και επι τας αισθησεις διηκον, και η δι' αυτων καταληψις και η περι τα αισθητηρια κατασκευη, καθ' ην τινες πονηροι γινονται και η ενεργεια αισθησις καλειται.—*Diog. Laert. in Zenone.*

B.

VERTIGO is an affection extremely curious, the consideration of which is connected with the theory of vision. The principal theories which have been invented to explain it are those of Wells and Darwin. The former refers it to certain motions of the eyes, of which the observer is unconscious, and which he supposes must occasion apparent rotation of objects. But, first, it may be objected, that motions of the eyes are always taking place; and it can hardly be said, that we are more conscious of this motion in ordinary cases than after revolving. When we attend to it we are conscious of it; but not otherwise. Secondly, the apparent motions of objects, after revolving, ought on this supposition to be backwards and forwards; whereas they are in fact always in one direction, which is precisely the opposite to that in which the observer has resolved. Thirdly, such motions of the eyes would probably render vision indistinct, if they affected it at all. Lastly, as is observed by Dr. Darwin, there is one experiment in which the vertigo is more distressing than in ordinary

cases; if a person turns round till he becomes giddy, looking in the mean time at a spot in the cieling over his head, or at his own finger held high over his head, and stops and looks horizontally, he now finds that the apparent rotation of objects is from above downwards, or from below upwards; *i. e.* the apparent circulation of objects is now vertical, instead of horizontal, making part of a circle round the axis of his eye. But the motions of the eye-balls, if they take place, here are in the ordinary direction, viz. horizontal.

Dr. Darwin's theory is, that spectra are formed in the eyes during gyration; or that a continuation of the motions excited in the optic nerve by those objects which engaged our attention, is the cause of the apparent rotation on ceasing to revolve. But it is sufficient to refute this hypothesis to observe, that on revolving with our eyes close shut, and opening them on ceasing to revolve, the gyration of objects is perceived; in this case no spectra can have been formed by the gyration. Dr. D. endeavours to elude this difficulty by stating, that differences of colour are perceived in revolving with the eyes closed in a lighted room, and therefore, that the eye gains spectra. But this is certainly not the case if the eyes are shut close, or if the person revolves in a dark room, and comes into the light, on ceasing to revolve; when in which cases, nevertheless, objects will appear to turn round. Besides, according to this theory, on ceasing to revolve, we should see not the objects on which we fixed our eyes, but some of those which were seen during some previous part of the gyration. Thus, in turning round in a room, in which the window was opposite to the fire place, if the person stops, and turns his eyes to the window, the window would not be the object seen to revolve, but the fire place, or some object placed in another part of the room, as it must be these that have formed spectra in the eyes during the gyration.

Although it may be difficult to give a complete explanation of this affection, it may be, in a great measure, referable to the general law, that sensations continue for a certain time after their original cause is removed. A peculiar sensation attends gyration. This sensation continues after we cease to revolve, and the apparent rotatory motion of objects takes place as a necessary consequence.

Dr. Darwin supposes that we balance ourselves by attending to the position of visible objects; and hence, when the perceptions of these have become changed, inability to preserve the equilibrium of the body ensues, and vertigo. But some observations shew that the reverse of this is the case, *i. e.* the perceptions of visible objects are regulated by associations with the consciousness of muscular efforts employed in keeping the body erect.*

* Wells on Single Vision with Two Eyes. — Melville in Edin. Physical and Literary Essays, vol. ii.

C.

SOMETHING very near resembling what is denominated irritability by modern physiologists, was most unquestionably recognized by the ancients, and many of the moderns prior to Haller and his followers — the oscillations of Charleton, Stahl, &c. Haller, however, at length published his real, or supposed, discoveries relating to this principle in the living body; and his pupils and admirers, Zimmerman, Zin, Caldani, Tissot, Fontana, prosecuted the investigation, following nearly the same tract. It was, however, very far from the case, that the Hallerian theory was universally admitted; many anatomists and physicians adhered to the mechanical explanation of the phœnomena in question, considering the contraction of the fibres of a muscle to be dependent on some.

Those enquirers into the subject, who coincided in opinion with Haller, so far as to admit that the phœnomena were to be referred to some cause essentially distinct from any thing in inanimate nature, and intimately connected with life, many of them rejected the peculiar opinions of the physiologist of Berne in many points. They contended that the nervous system was to be considered as the source from whence the power of motion in the animal body emanates. This was held to be the case, not merely with respect to the voluntary, but also the involuntary motions. There was no distinction between the vis nervea and the vis insita. This was the mode of thinking adopted by many of the Edinburgh school, then rising into celebrity, Whytt and Monro, who maintained a controversy with Haller.

De Haen attacked the doctrine of irritability in the objections drawn from pathology and practice—as did Wherloff.

Dr. Whytt referred the motions of the irritable fibre to the immaterial principle extended throughout the body. Cullen formed a system founded on analogous principles. The pathology which he adopted was founded on the supposition that the actions of the living body were distinct from any thing relating to dead matter; he imagined that the nervous system was the source of every thing in the animal body. Even the muscular fibre was derived from it. * Tissot, one of the most strenuous followers of the doctrines of Haller, has defended and explained them, in an epistle, addressed to Zimmerman. Whatever may be thought of the peculiar opinions of this school, it must be admitted that this writer has very successfully con-

* Tissot Epistolæ Medico-Practicæ, p. 159.

tended for the existence of powers in the animal body distinct from any in dead matter; a truth not universally recognized at the period when the treatise in question was published.

*Another writer endeavoured to render the theory of irritability subservient to his speculations, tending to establish the grossest system of materialism; an application which Haller always disclaimed himself in the strongest manner.

The irritability of plants has been much insisted on by many philosophers, who have from thence endeavoured to deduce arguments in favour of the independence of this property in animals on sensibility and the nervous system. But here there is great reason to doubt whether any analogy can be fairly established. It is impossible to deny that there are certain motions observed in the vegetable kingdom which cannot be accounted for on mechanical principles, or from any *known* properties of matter; but it by no means follows, that these phœnomena are proofs of the existence of a vital principle, or consequently, that irritability can be properly said to belong to plants, using the word in the same sense as when it is applied to express the contractile power of the muscular fibres of animals. There may possibly be many properties, hitherto undiscovered, existing in matter; and the phœnomena of vegetation may constitute a separate class of facts, either from mechanical and chemical principles on the one hand, or from vitality on the other.

The laws by which the contractions of the parts of vegetables take place are by no means similar to those which regulate the motions of the animal œconomy. Heat and cold are the principal agents in producing the motions of the leaves or other parts of plants, but these are not stimuli to the muscular fibres of animals, although they may perhaps modify the susceptibility to be acted on by stimuli. The division of a muscle necessarily occasions the immediate retraction of the two extremities; but if the leaf of the sensitive plant is slit with sharp scissars, the same does not happen, according to Dr. Darwin's observation.—*Zoonom.* sect. xiii. 5, 1.†

Many physiologists, and especially the author just cited, have contended for the existence of sensation in vegetables.

The *Scale of Nature*, which has been so much celebrated, and which appears plausible at first view, is a phantom which vanishes on a closer examination. The more observations are multiplied, the more specific differences every where present themselves. To adduce this supposed gradation of beings as an argument for the existence

* L'Homme Machine, par M. de la Metherie.

† See Brown's Observations on the Zoonomia.

of sensibility or irritability in plants, is defending one hypothesis by another still more doubtful.

Those who deny the influence of the nerves on irritability, yet admit that to sensibility and voluntary motion these organs are essentially necessary. But those animals which are supposed to be destitute of a nervous system, shew evident marks of their possessing sensibility as well as a power of voluntary motion. The argument drawn from this source, therefore proves more than intended, by those who adduce it in the present question.

A priori, considering the uniformity which prevails throughout the whole animal kingdom in the structure of the organized body, notwithstanding apparent variety, the probability seems to be, that organs so essential as the brain and nerves are not entirely wanting in any species. In all animals a circulatory system is to be met with, in all digestive organs, in all a muscular structure; can we consistently with analogy conceive that the nervous system, which certainly yields to none of these in its importance, is in any totally wanting?

It is hardly worth while to enumerate, or still less to examine particularly, the different hypotheses which have been framed to explain the motion of the muscles, or the structure of the ultimate fibre. Most physiologists now are agreed, that such enquiries are entirely fruitless, at least in the present state of science; if even any discovery is made respecting these topics, it must be by means of some mode of investigation which at present is unknown. The remark which a late philosopher made respecting gravitation, may very well be applied to muscular motion, that—"the human mind was never "better employed than in investigating the phœnomena, nor worse "than investigating the cause of them."

The motto prefixed to a very ingenious dissertation—De Actione Musculari—was

"Latet arcana non enarrabile fibra."

The ultimate fibre has never been detected. Microscopical observations, always liable to error, are the only means.

The latest observations, or speculations, as they may more properly be called, are those of the Abbé Fontana and Dr. Monro.

D.

WILLIS De Motu Musculari, objects to the opinion, that the mind has a power of exciting the muscular fibres into action, as—"Hoc esset

" *anima sensitivæ* virtutem supernaturalem et quasi dirinam attribu-
" ere; nempe quod eadem mero afflatu suo, corpora gravia ac mole
" prægrandia, quo libitum erit, deflectere, aut cogere posset. *Porro*
" quem ob finem *organa motiva* tam miro artificio et multiplici dis-
" crimine fabricantur, nisi ut machinarum ritu concinna partium
" structura et apparatu quasi mechanico operationes suas perficiant?
" Perfecto non difficile erit *musculi* immo totius functionis κινητικης
" exercitia, ad mechanicæ leges revocare, et juxta regulas et canones
" ejus explicare."

Malbranch has advanced an opinion somewhat similar, with reference to his system of occasional causes.

To move them (our limbs), we must have animal spirits, and convey them, by certain nerves, into such and such muscles, to swell and contract them; for, by this means the arms move: or, according to the opinion of some, we know not yet how it is performed. And we see that men who do not so much as know they have spirits, nerves, and muscles, to move their arms, yet move them with as much facility as those that understand anatomy best. It is then granted, that men will the motions of their arms, but it is only God that can, and knows how to remove them. If a man cannot throw down a tower, at least he knows well what must be done in order to it. But there is no man that knows so much as what he must do to move one of his fingers by the help of his animal spirits; how then can men move their arms?—*Malbranch on Truth*, vol i. p. 188.

This mode of reasoning is precisely similar to that made use of by Haller against the Stahlian school, and which has been carried still farther by some speculatists, so as to prove the mechanism of the human frame in all its functions and affections.

E.

Dr. DARWIN supposes, that the perpetual flow of ideas in dreams serves the purpose of preventing an accumulation of sensorial power in the organs of sensation, which would otherwise take place, and occasion delirium on awaking. But why then, it may be asked, does not delirium take place on awaking from sleep, during which the person has not dreamt at all?

Haller asserts,—" Somnus adeo oritur vel a simplici defectu, inco-
" pia et immobilitate spirituum vel a compressione nervorum sem-
" per autem a difficiliori spirituum per cerebrum motu."—*Prim. Lin.* sect DLXXXV. This theory, he states, is confirmed by observing the causes of watchfulness. Sleep is prevented by all those things

which produce "copiosos spiritus," aromatics, stimulants.—"Qui "ad caput stimulantes subtiles, particulas mittant unde incitatus "paulum sanguinis in cerebro motus et dilutior indoles plus spiritu- "um in dato tempore separat. Deinde somno resistunt curæ graves "et meditationes cum studio et adfectu. Dolores corporis et animi "sensationes prævalidæ quæ omnia non sinunt spiritus in communi "sensorio quiescere aut poros collabi. Priora ergo spirituum copi- "am faciunt, hæc motum augent." It is obvious, however, that all the circumstances mentioned here, by averting sleep, and others might be mentioned, as bodily motion, by exciting the organs of sense and motion, must occasion an exhaustion of animal spirits, according to the theory which imagines these agents concerned in sensation and motion. Hence the "incopia spirituum" would be the consequence, and sleep, in all cases, be immediately brought on, instead of being prevented, so far as this cause had influence, however the other conditions stated might be affected.

F.

THE vitality of the blood, or the existence in this fluid of properties analogous to those of the solid organised parts of the living body, has been maintained by many speculatists; and a late celebrated physiologist revived the hypothesis, and defended it with many new illustrations and parts, the property of coagulation, or becoming solid on extravasation; its forming new parts; its not acting in an extraneous body when extravasated into any internal cavity, and the power of self-preservation; not putrifying under circumstances in which that process takes place in animal matter in general when out of the body, are the principal grounds on which this theory has been maintained by Mr. Hunter and his followers. The truth of it, however, is by no means universally or generally recognized; and farther proof seems wanting to establish it fully.

The strongest argument, perhaps, is that derived from the blood not undergoing putrefaction, although in circumstances the most favourable to the taking place of that change. Temperature 98, slight motion, &c. The renovations of the substance of the blood, by the addition of fresh chyle, and the secretions which carry off those parts which are become effœte, are too slow and gradual to prevent putridity from occurring, without some concurring cause; and this can be hardly any other than the vital principle acting in some way or other.

G.

CEREBELLI autem officium esse videtur, spiritus animales nervis "quibusdam suppeditare: quibus actiones involuntariæ *cujusmodi* "*sunt* cordis pulsatio, respiratio αβιατος, alimenti concoctio chyli pro- "trusio et *multæ aliæ*, quæ nobis insciis aut invitis constanti ritu "fiunt peraguntur." Independent, however, of this supposition, that the nerves which are subservient to the vital motions arise solely from the cerebellum, those which belong to the voluntary actions from the cerebrum, Willis states some circumstances relating to the manner in which the animal spirits are formed in these two organs. The flow of the animal spirits from the cerebellum being constant, while that from the cerebrum is occasional and irregular.—*Opera Willisii*, 4to. p. 52, 53.—*Cerebri Anatome.*

Haller remarks of this theory, that it is one of those, which, at first point of view, appearing specious and plausible, as to gain a complete solution of the difficulty, are found to be totally erroneous. Very simple views of nature are seldom just.

The question is very intimately connected with that of muscular motion in general, and indeed is hardly any other than a particular case of it. The other involuntary muscles, as the intestines, and the glandular secretions, or the contractions of the excretory ducts.]

Haller's investigations have at last put the question on a better footing than it was before. It is considered as a function of the living body, and not dependent on mechanical causes.

With respect to the fact, that the division of the cardiac nerve does not put an immediate stop to the motions of the heart, it seems to have been ascertained by Willis, in an experiment instituted by him, although he seems to wish to evade the conclusion. Haller, however, was the first who stated, in a positive manner, without answering very satisfactorily the objections which may be brought against it. Influence of the passions, apparent want of activity of nerves of the heart, are this hypothesis. What is to be considered as the explanation of these real or supposed instances of the will having acquired a power over the actions of the heart, so as to produce syncope at pleasure?

Vide Nicholls de Anima Medica.

Cheyne, English Malady.

Fontana relates, that Girardi, an Italian anatomist, had a power over his circulation.

The most powerful stimulus which is known to the voluntary muscles has been imagined to be totally inert with respect to the heart.

Galvanism, Dr. Fowler could not produce any contractions in this organ by the galvanic influence; and some others have met with the same want of success. Aldini, however, met with a different result. He found that contractions were actually excited in the heart by the galvanic battery, unknown at the period of Dr. Fowler's researches. There is no doubt, however, that the voluntary muscles are in a much greater degree excitable by this agent, whatever its nature may be, than those which belong to the other class.

H.

THE real nature of the hepatic function does not appear to be well ascertained. The purpose which the bile serves in the animal œconomy, has, in all periods of medical science, attracted the attention of speculatists on subjects of physiology and pathology. The idea which prevailed among the ancients was, that this fluid was excrementitious; and this opinion passed current until Sylvius invented a new system, imagining that the bile was in some manner subservient to the purposes of digestion. It has been stated by some, that he was anticipated by Nemesius, a writer in the fourth century (Friend Histor. Medicinæ, p. 199), in these speculations. However, since this author, the liver has been generally ranked among the chylopoictic viscera. The precise manner in which it acts has not been generally agreed on, as many suppose that the bile is merely a stimulus to the intestines, exciting the peristaltic motion, which is consequently deficient when the passage of this fluid into the duodenum is impeded. A late writer on this subject has controverted the fact of bile having this effect. However this may be, it seems hardly consistent with the size and apparent importance of the liver in the animal œconomy, that an effect of this kind should be the sole purpose answered by it. Many physiologists imagine that digestion is in some degree promoted by the action of the bile on the alimentary mass, and theories have been invented to explain the particular manner in which this takes place. The alkaline part of the bile uniting with an acid, supposed to be contained in the chyme, a precipitation of the chyle from this fluid is produced. But besides the difficulties which attend this supposition, in a chemical point of view, the well known fact of the passage of bile into the intestinal canal being prevented for a long period, during which any

obstruction to the essential part of digestion would be inconsistent with the continuance of life, tends to overturn the hypothesis. Haller supposes that the liver answers some other purpose besides the secretion of bile.—" Non possum non suspicari præter bilis secretio-" nem esse hepatis peculiarem utilitatem." The foundation for this opinion must be the apparent inadequacy in the use answered by the bile to the apparatus employed in secreting it. Hence it must rest on the importance of the function which this secretion fulfils. Lately the old opinion, that bile is merely an excrement, has been revived.* And perhaps, on the whole, it may be considered as the most probable that has yet been suggested. The sensible qualities of the fluid in question, its acrimony, and the quantity in which it is found, certainly afford analogies with those secretions which are known to be excrementitious. Taken in this point of view, the biliary secretion becomes of more real importance in the system, than in the usual way of considering the subject. The urinary secretion is of great importance to the health; and any impediment to its taking place, is well known to cause very fatal effects.

I.

SOME philosophers have attributed growth to the mineral kingdom. Linnæus begins his celebrated climax of the productions of Nature with " lapides crescunt." If, however, by growth, is here to be understood any thing analogous to the mode by which the parts of animals are formed, or increase in size, or any process depending on organization, or a power of assimilating heterogeneous substances, the assertion seems without foundation. A mineral deposited in a situation where a supply of parts, similar to those of which it is composed, has access to it, increases in size, as in water impregnated with earthy or saline matter; in this sense it may be said to grow in the same manner as a piece of cloth may be said to grow in the loom, or a stone wall while it is building. But this is not the sense which has been affixed to the proposition by the naturalists mentioned above.

* Johnson's History of Animal Chemistry.

An opinion very similar to those of Dr. Darwin, appears to have been very ancient, respecting nutrition.

" Quemadmodum planta radicum fibris, ut animatore de terra " tanquam de penu, et ventre quod utile est naturæque suæ conveni- " ens exugit atque tandem in suam substantiam convertit. Ita sin- " gulis partibus insita est facultas quod effluit de massa sanguinis " veluti judicio et delectu attrahendi, hac vi cerebrum pituitosum " sanguinem allicit, &c."—*Riolan in Fernel de Abd. Rerum Causis*, p. 109.

" Ut Plantarum sic animalium partes cum delectu trahunt naturæ " suæ conveniens alimentum, similitudine substantiæ inquam non " aliter quam magnes ferrum."—*Ibidem.*

This process was ascribed to the anima vegetans.

FINIS.

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